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THE UNIVERSITY OF MICHIGAN

COLLEGE OF ENGINEERING

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Space Physics Research Laboratory

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Solar Extreme Ultraviolet Sensor and  
Advanced Langmuir Probe

PROGRESS REPORT

December 14, 1992

Prepared on behalf of the project by:

N. R. Voronka  
B. P. Block  
G. R. Carignan

(NASA-CR-191972) SOLAR EXTREME  
ULTRAVIOLET SENSOR AND ADVANCED  
LANGMUIR PROBE Progress Report  
(Michigan Univ.) -80 p-



Under Contract with:  
National Aeronautics and Space Administration  
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Progress Report  
December 14, 1992

Solar Extreme Ultraviolet Sensor and  
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Prepared by:

Nestor R. Voronka  
Bruce P. Block  
George R. Carignan

Space Physics Research Laboratory  
University of Michigan  
Ann Arbor, Michigan 48109-2143

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## **1.0 Introduction**

For more than two decades, the staff of the Space Physics Research Laboratory (SPRL) has collaborated with the Goddard Space Flight Center (GSFC) in the design and implementation of Langmuir probes (LP). This program of probe development under the direction of Larry Brace of GSFC has evolved methodically with innovations to: improve measurement precision, increase the speed of measurement, and reduce the weight, size, power consumption and data rate of the instrument. Under contract NAG5-419 these improvements were implemented and are what characterize the Advanced Langmuir Probe (ALP).

Using data from the Langmuir Probe on the Pioneer Venus Orbiter, Brace and Walter Hoegy of GSFC demonstrated a novel method of monitoring the solar extreme ultraviolet (EUV) flux. This led to the idea of developing a sensor similar to a Langmuir probe specifically designed to measure solar EUV (SEUV) that uses a similar electronics package. Under this contract, a combined instrument package of the ALP and SEUV sensor was to be designed, constructed, and laboratory tested. Finally the instrument was to be flight tested as part of a sounding rocket experiment to acquire the necessary data to validate this method for possible use in future earth and planetary aeronomy missions.

## **2.0 Summary of Project Activities**

The primary purpose of this contract was to develop the electronics hardware and software for this instrument, since the actual sensors were supplied by GSFC. Due to budget constraints, only a flight model was constructed. These electronics were tested and calibrated in the laboratory, and then the instrument was integrated into the rocket payload at Wallops Flight Facility where it underwent environmental testing. After instrument recalibration at SPRL, the payload was reintegrated and launched from the Poker Flat Research Range near Fairbanks Alaska. The payload was successfully recovered and after refurbishment underwent further testing and development to improve its performance for future use.

### **2.1 Project Hardware**

The SEUV/ALP hardware was designed for the sounding rocket mission but also with the intention of allowing it to be easily upgradable to a flight qualified instrument with minimal effort. The entire instrument consisted of a Flight Computer with Telemetry Interface, a Grid Voltage Generator Board and two VA Generator/Electrometer Boards. In addition, ground support equipment was designed that would allow the instrument to

operate in a laboratory setting as well as support the instrument once it was integrated into the rocket payload.

### **2.1.1 Flight Computer**

The processor chosen for the flight computer was Intel's 80C916 12MHz microcontroller which was specifically designed to be used in embedded systems such as this one. The advantages of using this processor were that it has two timers, an eight channel A/D converter, and a serial port. The additional functionality of this processor provided for a smaller and more power efficient flight computer.

The flight computer has an address space of 64K: 8K was used for the boot ROM, 32K was used for the program EEPROM (electrically-erasable PROM), 8K was used for battery-backed RAM, and 4K was used for memory mapped I/O. A watchdog timer was also integrated into the flight computer, which would reset the flight computer should the flight program crash. The flight computer also had some signal conditioning hardware to allow the eight A/D channels to be used for housekeeping purposes.

The programming of the flight computer was done via the serial port. Once the flight program was compiled, it was uploaded to the flight computers EEPROM using the ground support computer communicating over a RS-422 link.

### **2.1.2 Grid Voltage Generator**

The solar EUV sensor has three grids which must be biased with varying potentials ranging from approximately -50V to +50V. The Grid Voltage Generator Board has a quadruple 12-bit digital to analog converter (DAC) which produces voltages in the -10V to +10V range. Three high voltage amplifiers were used to amplify these signals to the required levels. The fourth DAC was not used for the rocket mission, but its output signal is available externally should it be required in the future. The Grid Voltage Generator Board also has a programmable timer which generates two shift clocks (one each for the SEUV and the ALP) for the optocoupled electrometers in the VA Generator/Electrometer Boards. In addition, there are buffers which were used to condition the grid voltage signals so that the rocket's telemetry system could monitor these signals during the flight.

### **2.1.3 VA Generator/Electrometer**

The VA Generator/Electrometer Board is a result of extensive work done at SPRL to improve the accuracy and speed of the Langmuir Probe instrument. The VA Generator is constructed similarly to the Grid Voltage Generators except that a single 16-bit DAC is used to allow the VA to have a -65V to +65V ranges with 2mV resolution. The

electrometer makes its measurements while floating on the applied potential. Data signals are optically coupled from the flight computer to the electrometer gain registers and the 12-bit A/D converter. There is also a relay circuit which is used to apply +125V to the sensor to clean the sensor by electron bombardment using ionospheric electrons.

#### **2.1.4 Ground Support Equipment**

The ground support equipment for this instrument is contained in a single suitcase with the addition of a notebook sized IBM PC compatible computer. The suitcase contains a power supply and RS-422 to RS-232 interface hardware. The ground support computer is used to develop, compile, and upload object code to the flight computer. In addition, there exists software that allows one to operate the instrument in a laboratory environment where one sends commands to the instrument and receives data back from the instrument via the RS-422 link. This software has the capability of displaying the resulting I-V curves in real-time as well as saving them to disk for later analysis.

### **2.2 Project Software**

The following paragraphs describe the real-time flight control software of the SEUV/ALP instrument. This software was designed to operate the instrument at the highest sampling rate possible without sacrificing instrument reliability, accuracy, and the portability of the flight code. The instrument can operate either in flight mode or test/laboratory mode without reprogramming the flight computer. In flight mode, the instrument steps through a sequence of pre-programmed measurement modes and telemeters the acquired data. In test/laboratory mode, the instrument requires a ground support computer to control the instrument and record measured data.

#### **2.2.1 Overview**

The majority of the software was written in a high level language, ANSI C, and was compiled with the Archimedes 80C196 cross-compiler. A high level language was used to reduce software development time. ANSI C was chosen because it is a high level language that is well suited for real-time embedded systems programming. Some assembly language programming was necessary and the Archimedes 80C196 cross-assembler was used to produce object code.

In early development phases of the software, it was decided that the use of a real-time kernel and operating system was not necessary, because it would produce overhead that would reduce the temporal resolution of the instrument. Instead, the instrument was to perform its tasks within a predefined measurement interval. In that interval, current was to

be measured, voltages were to be adjusted, telemetry was to be sent and housekeeping information gathered. This concept allowed the instrument to have temporal resolution that was dictated by the analog hardware and not by the speed of the flight computer.

The flight software was designed in modules or processes (see drawing in Appendix A). Each process or module is a collection of functionally similar tasks or routines, and these processes are described below.

### **2.2.2 Module Descriptions**

**MAIN** -- This is the highest level control process of the flight software system. This process is initiated upon reset of the system -- either powerup, manual or watchdog timer reset. This process can operate in two modes: flight or bench mode.

After performing all necessary initialization, this process goes into bench mode. In this mode the process awaits for commands from the serial port continuously until a launch signal is detected. The commands are processed and executed by the COMPROC process and can be used to configure or test the instrument during pre-launch operations or to operate the instrument in a laboratory setting for measurements or testing. After the launch signal is detected, this process is in flight mode and measurement sequencing is initiated and controlled by the MODES process. To insure that measurements are made at regular time intervals in flight mode, after the necessary tasks are done, the CPU is placed into a power-conserving sleep mode and wakes up by an interrupt generated by the TIMER process.

**COMPROC** -- This process parses, limit checks and executes all commands received from the serial port from the SERIAL process. The commands are executed by referencing a function pointer in a lookup table allowing a very flexible and expandable command processor. Currently, there are commands for testing, calibration, hardware debugging, mode debugging, and laboratory measurement programmed in the command processor. The results from these commands are either sent via the SERIAL process to the ground support computer or via the TM process to the telemetry interface.

**MODES** -- The MODES process executes a pre-programmed sequence of modes. There are two tables (one for the SEUV and one for the ALP) of ordered mode names which are used to control this sequence. These tables can be either compiled in, or programmed by commands in the COMPROC process. This process controls measurement sequencing by communicating to the MODES2 process which step of which mode is to be executed. The current measurement mode and step are stored in zero-powered RAM to allow the instrument to continue operation where it left off after a power failure or a watchdog timer reset.

The mode names are stored in a table also, along with function pointers and other information, to facilitate the addition of new modes.

**MODES2** -- This module is not a single process but a collection of processes that control the activities necessary to perform scientific measurements (adjusting gains, setting applied voltages, measuring currents) by executing I/O routines. Each measurement mode process is controlled by a mode step number that is received from the MODES process. The modes that are programmed in this module are specified by the *Modes of Operation* document (see Appendix B).

**TM** -- The process generates and transmits telemetry either over the dedicated telemetry channel or via the serial port. The SEUV/ALP instrument uses packet telemetry conforming to the Consultative Committee's on Space Data Systems (CCSDS) packet telemetry standard as specified in the CCSDS 102.0-B-2 Blue Book. This telemetry system uses packet error control as specified in the CCSDS 100.0-G-1 Green book. This process assembles data into packets and when completed, copies the assembled packets into the telemetry system interface hardware.

**SERIAL** -- This is an Interrupt Service Routine(ISR) module whose task is to receive data from the serial command port and transmit it to the COMPROC process, and to send data back to the ground support equipment during testing and laboratory measurement setups. To maximize the throughput and efficiency, this process was programmed in 80C916 assembly language.

**TIMER** -- This ISR module initializes the CPU's timers and acknowledges interrupts from the CPU. The timers are used to provide an instrument clock which ensures that current measurements are made at regular time intervals, and to provide a start time for all measurement modes which simplifies the data analysis process. This module was programmed in assembly language also.

**I/O** -- This module is a collection of routines that communicate directly with the instrument hardware (VA generators, A/D converters, registers, timers, etc.). The purpose of this module was to keep all device dependent programming together to reduce the effort necessary to modify the flight code for various hardware configurations. Any calibration information used in the instrument is also contained in this module.

### **2.3 Flight Experiment Details**

The combined SEUV/ALP instrument was part of Dr. William Sharp's sounding rocket mission 27.133 UE. The instrument was piggybacked onto Dr. Sharp's payload and was launched by a Nike-Black Brant VC from Poker Flat Research Range (65°07'N 147°28'W) at 206:13:36:00 UT 1992. The payload achieved an apogee of 233.36 km,



and was successfully recovered with the SEUV/ALP instrument not sustaining any damage.

The instrument was partially successful in achieving its objectives which were twofold: to acquire SEUV data to verify the measurement model, and to perform an engineering test of the combined SEUV/ALP electronics. A satisfactory number of SEUV measurements were made, and are currently being processed. Due to a component failure, the ALP channel failed and no measurements were made. However this does not constitute a failure to meet the second objective since an identical unit which was used to measure SEUV currents did not fail.

## **APPENDIX A**

### **System Specifications and Block Diagrams**

## Langmuir Probe/Solar EUV Electronics Data Sheet



### • Applied Voltage Generators:

2 Generators with 16 bits of resolution  
Range: -65.536V to 65.534V in 2mV increments

### • Grid Voltage Generators:

3 Generators with 12 bits of resolution  
Range: -51.200V to 51.175V in 25mV increments

### • Electrometers:

2 Electrometers sampled with 12 bits resolution

Range 1: -66 $\mu$ A to +66 $\mu$ A

Range 2: -4 $\mu$ A to +4 $\mu$ A

Range 3: -200nA to +200nA

Range 4: -15nA to +15nA

### • Flight Computer:

Custom Computer based on Intel 80C196 12MHz processor w/watchdog timer  
32K of EEPROM Program Memory  
8K of Boot/Loader ROM  
8K of Battery Backed RAM

### • Telemetry/Command Interface:

Serial TM Interface to PCM stack at 1250 bytes/sec  
(Packet TM conforming to CCSDS 102.0-B-2 standard)  
Serial RS-422 Command/TM Interface at 9600 baud

### • Size of Electronics:

10.180" (L) x 5.930"(W) x 5.610"(H)

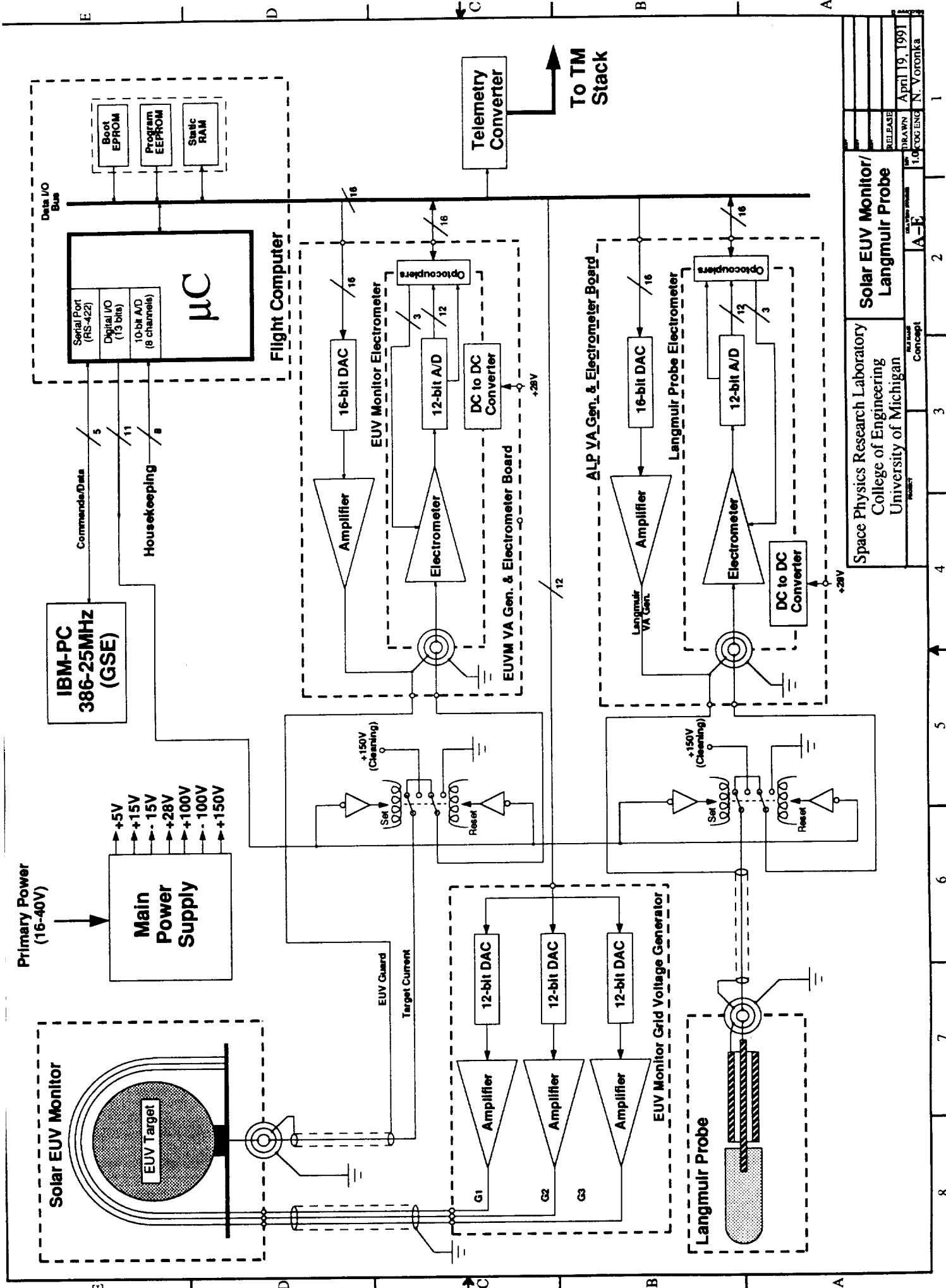
### • Mass of Electronics:

3.75 kg

### • Power Consumption:

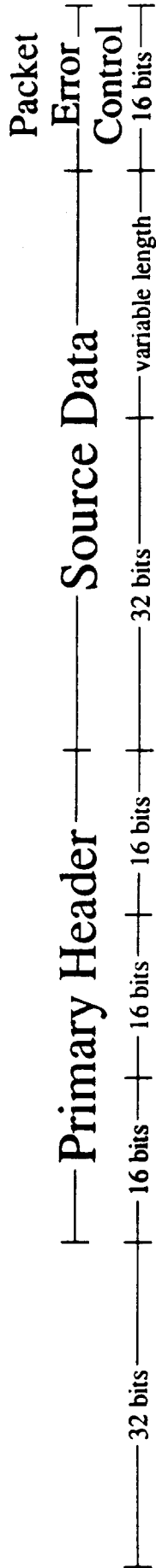
(2) $V_a$ Generator/Electrometers	2.10 W
Grid Voltage Generators	2.94 W
CPU/Telemetry	2.23 W



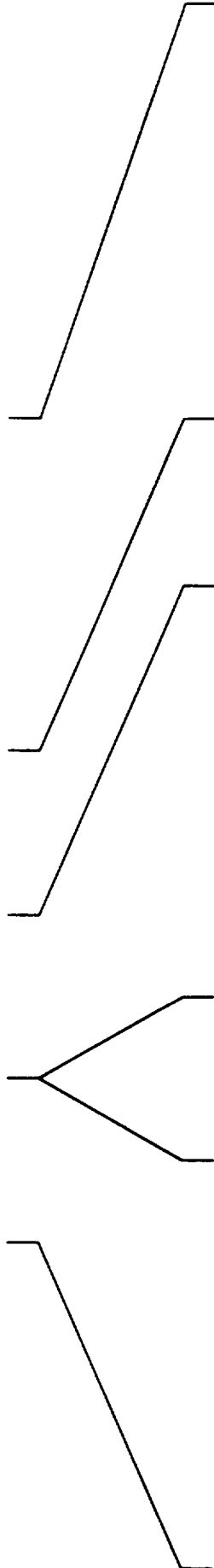


Space Physics Research Laboratory	Solar EUV Monitor/	1
College of Engineering	Langmuir Probe	2
University of Michigan		3
REVISION	REVISION	4
DATE	DATE	5
DRAWN	DRAWN	6
1.0 COG ENG	1.0 COG ENG	7
N. Vortanka	N. Vortanka	8
APR 19, 1991	APR 19, 1991	
RELEASE	RELEASE	





Primary Header		Source Data		Packet Error Control
32 bits		16 bits	16 bits	16 bits
variable length		32 bits	variable length	16 bits
Synchronization Marker		Packet Identification	Packet Sequence Control	Packet Length(Bytes)
Secondary Header		Data		CRC



Packet Identification		
Version #	Packet Type	Secondary Header Flag
000	0	1
		11

00111110000 -- SFM  
 0100001111 -- ALP  
 1111111111 -- Idle  
 10010010101 -- Housekeeping

Packet Sequence Control	
Segmentation Flags	Source Sequence Count
2	14

00-- Continuation Segment  
 01-- First Segment  
 10-- Last Segment  
 11-- Unsegmented Packet

Secondary Header (User Defined)		
Version	Header Length	Mode #
2	6	8
00	000011	x23 -- SFM_STD
		x2B -- SFM_HR
		x26 -- SFM_GT
		x29 -- SFM_GS
		x27 -- SFM_RPA
		x2E -- SFM_CLN
		x40 -- ALP_SPT
		x41 -- ALP_STD
		x42 -- ALP_HR
		x44 -- ALP_MR
		x48 -- ALP_CLN

#### Notes:

1. The above format conforms to the CCSDS Packet Telemetry format as specified in the CCSDS 102.0-B-2 Blue Book (January 1987).
2. The Frame Synchronization Marker when NOT using Reed-Solomon Encoding is 0x1ACFFC1D.
3. The error control word is a cyclic redundancy code generated using the generator polynomial specified in the CCSDS Telemetry 100.0-G-1 Green Book (December 1987.)

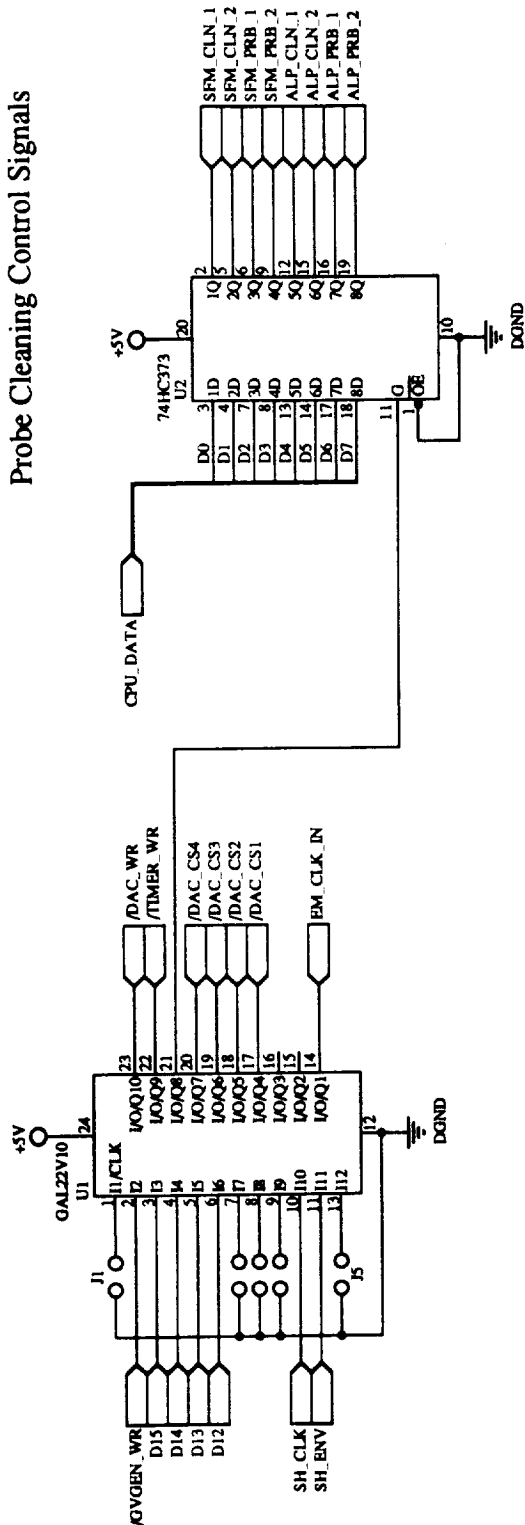
Space Physics Research Laboratory		SFM/ALP	
College of Engineering		Packet Telemetry	
University of Michigan		Data Format	
		A-E	
		RELEASE	
		FOR ENGIN N VORONKA	

## **APPENDIX B**

### **SEUV/ALP Electrical Drawings**



# Probe Cleaning Control Signals

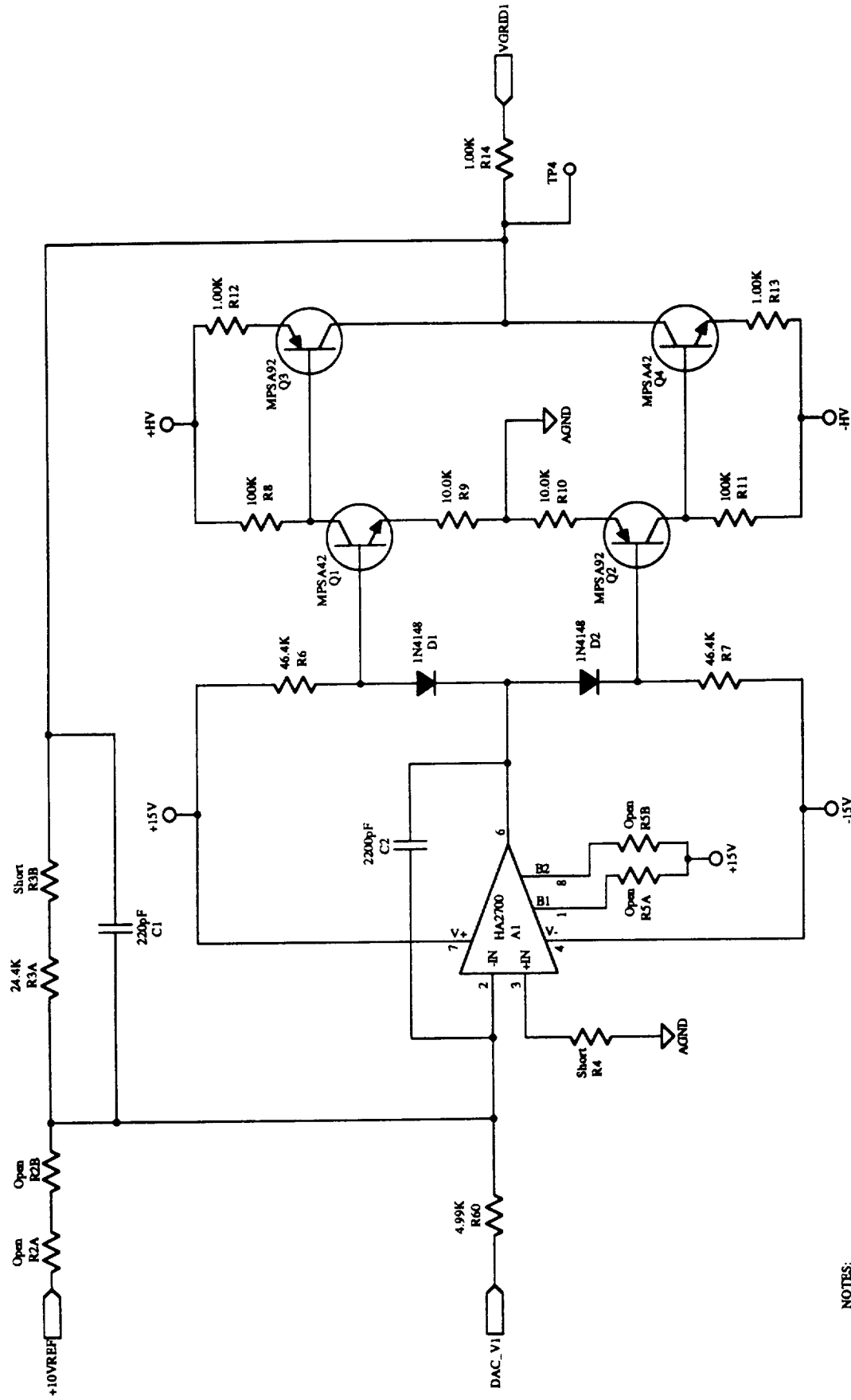


NOTES:  
1. Unless otherwise specified, all resistors are type RNC55 and all capacitors are type CKR05.

To write to:	Data must be of the form
Programmable Timer	00XXXXXXXXXXXXXXXXXXXX
Quadruple DAC	01AAXXXXXXXXXXXXXXXXXX
Octal Latch	10XXXXXXXXXXXXXXXXXXXX

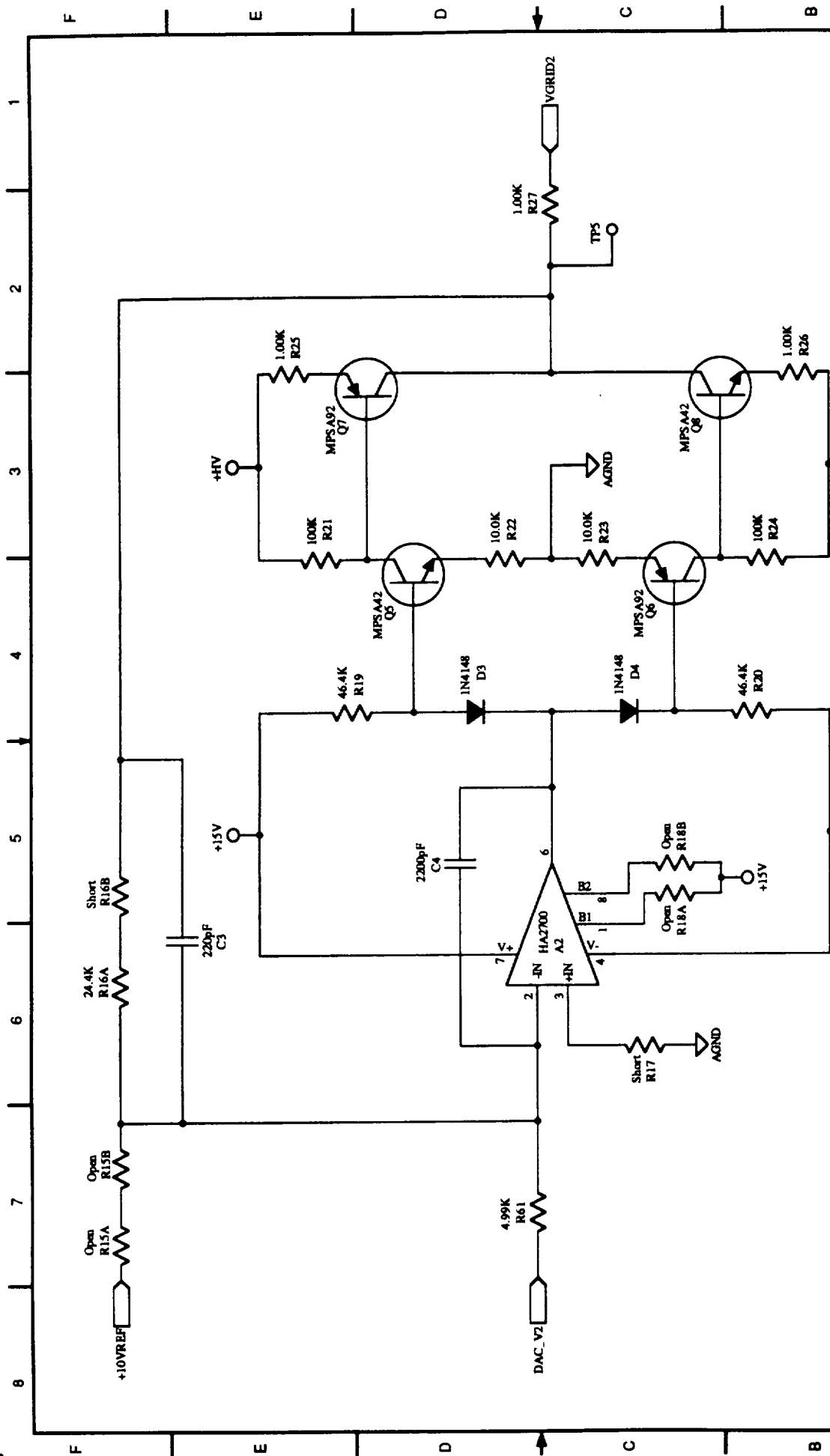
Space Physics Research Laboratory College of Engineering University of Michigan	Decoding PAL & Latch Grid Voltage Generator Solar Flux Monitor	REV. REV. CONTROL RELEASE DATE 1991 11.1
PRODUCT NAME SFM/ALP	PROJECT NUMBER 11.1	ENGINEER N. YOROKURA





NOTES:  
1. The total resistance of R5A+R5B must be approximately 20K ohms.

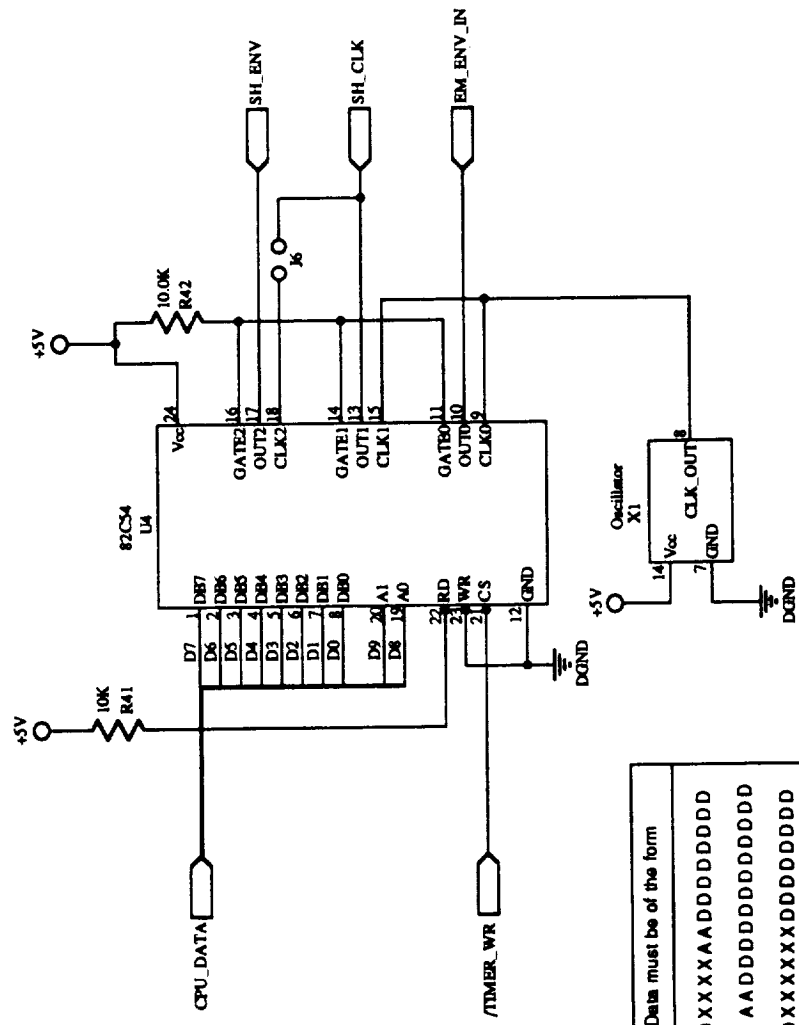
Space Physics Research Laboratory	Grid 1 Bipolar Amplifier	REV	Nov 14, 1992
College of Engineering	Grid Voltage Generator	REV	
University of Michigan	Solar Flux Monitor	CONTROL	
		RELEASE	
		DESIGN	SEP 15 1991
		DRAWN	Block/Victoria
		BRUNSWICK	



NOTES:  
 1. The total resistance of R18A+R18B must be approximately 20K ohms.

Space Physics Research Laboratory	Grid 2 Bipolar Amplifier	REV	Nov 14, 1992
College of Engineering	Grid Voltage Generator	REV	
University of Michigan	Solar Flux Monitor	CONV	
PROJECT NAME: SPM/ALP	ISSUED FOR: PROJECT	RELEASE	
DATE: 10/1/92	BY: J. J. J.	DATE: 10/1/92	
		BOOKED	



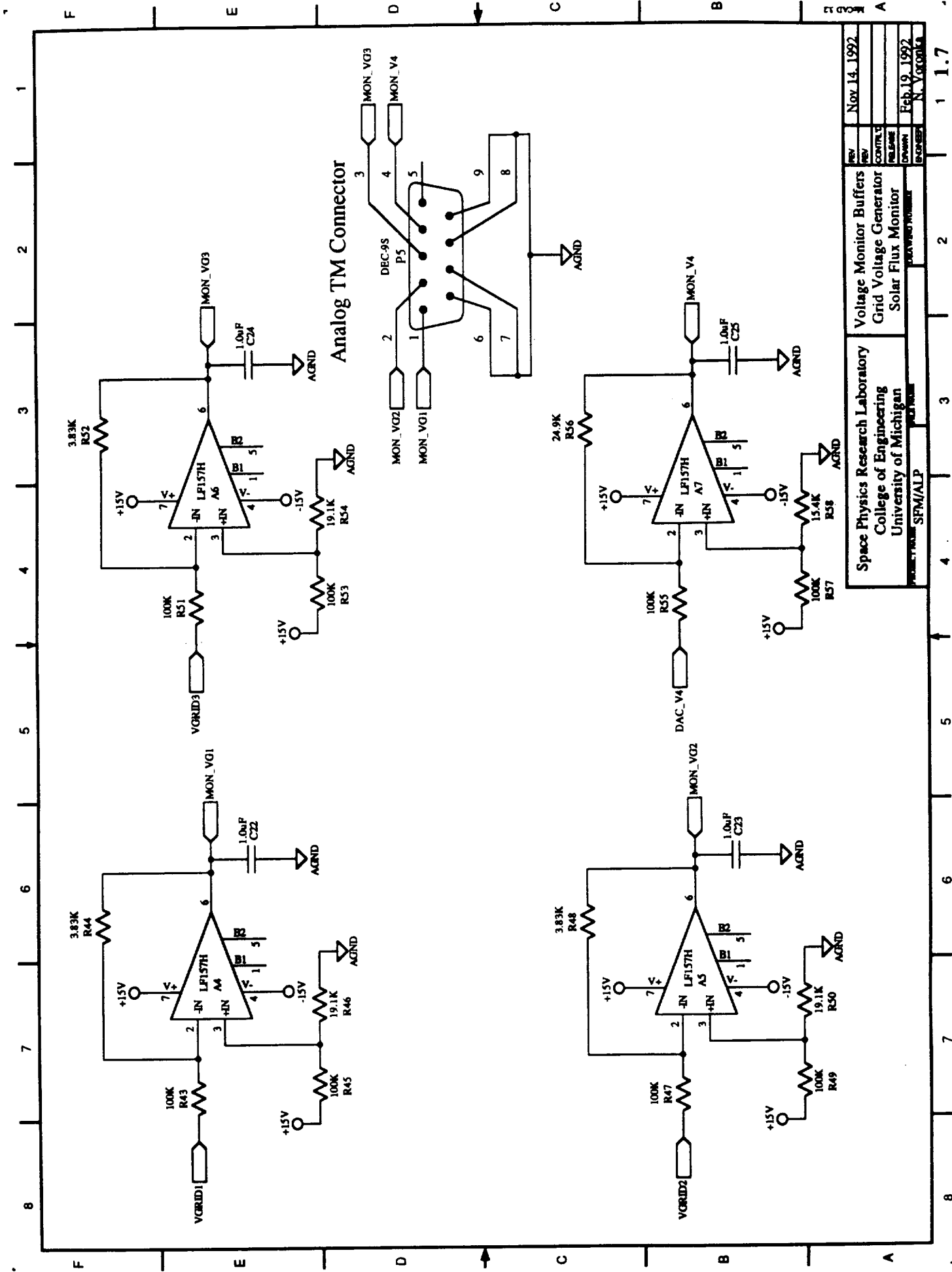


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Quaduple DAC	01AAXXXXXXXXXXXXXX
Octal Latch	10XXXXXXXXXXXXXXXX

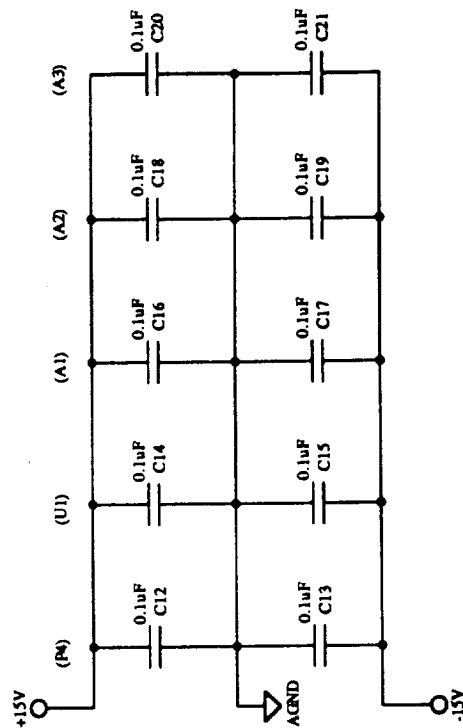
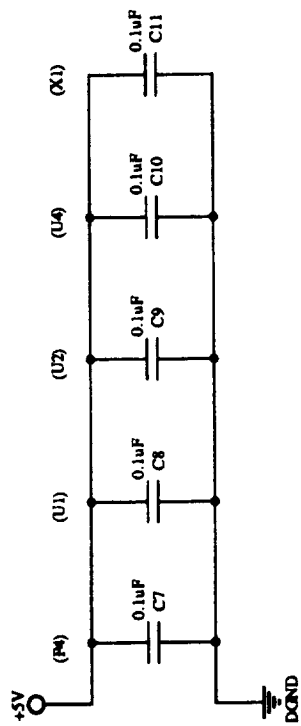
REV	1.0
REV	1.1
CONT'D	
RELEASE	
DATE	Oct 12 1991
DESIGNED BY	N. V. GONDA
CHECKED BY	
APPROVED BY	
PROJECT NO.	SFM/ALP

Space Physics Research Laboratory  
College of Engineering  
University of Michigan

Programmable Clock  
Grid Voltage Generator  
Solar Flux Monitor

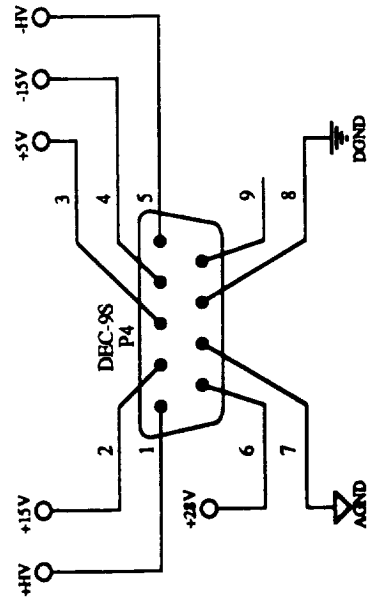
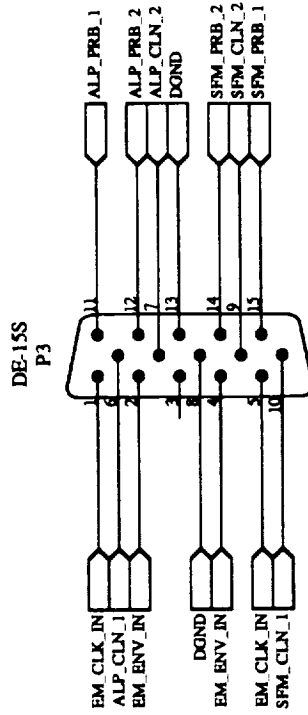
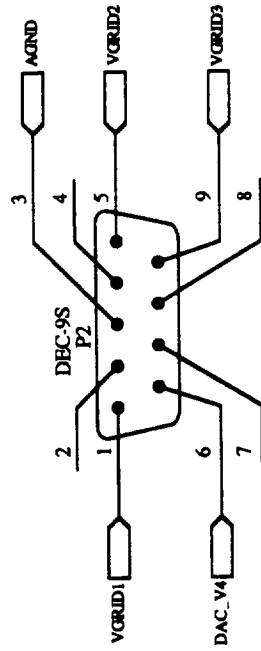
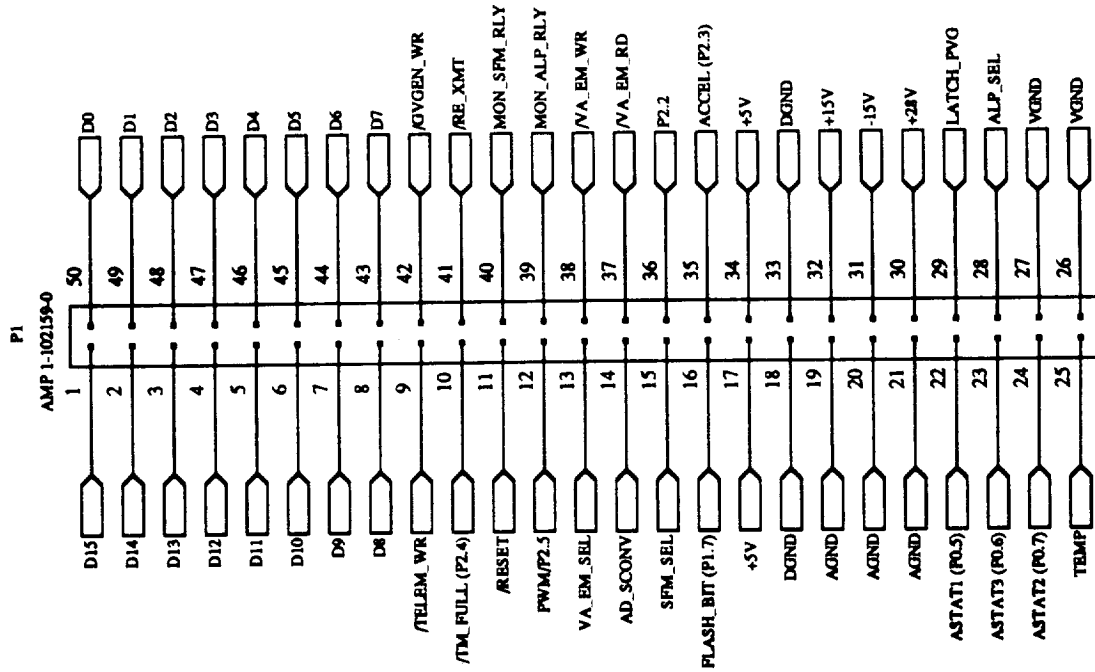


Space Physics Research Laboratory	Voltage Monitor Buffers	REV	Nov 14, 1992
College of Engineering	Grid Voltage Generator	COMPLT	
University of Michigan	Solar Flux Monitor	DESIGN	Feb 19, 1992
SPM/ALP	DESIGN NUMBER	DESIGNER	N. Varghese

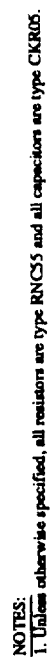


Space Physics Research Laboratory College of Engineering University of Michigan	Power Supply Filters Grid Voltage Generator Solar Flux Monitor	REV REV CONTINUED RELEASE DOWNGR Feb 20, 1991	SPM/ALP N. Yocum
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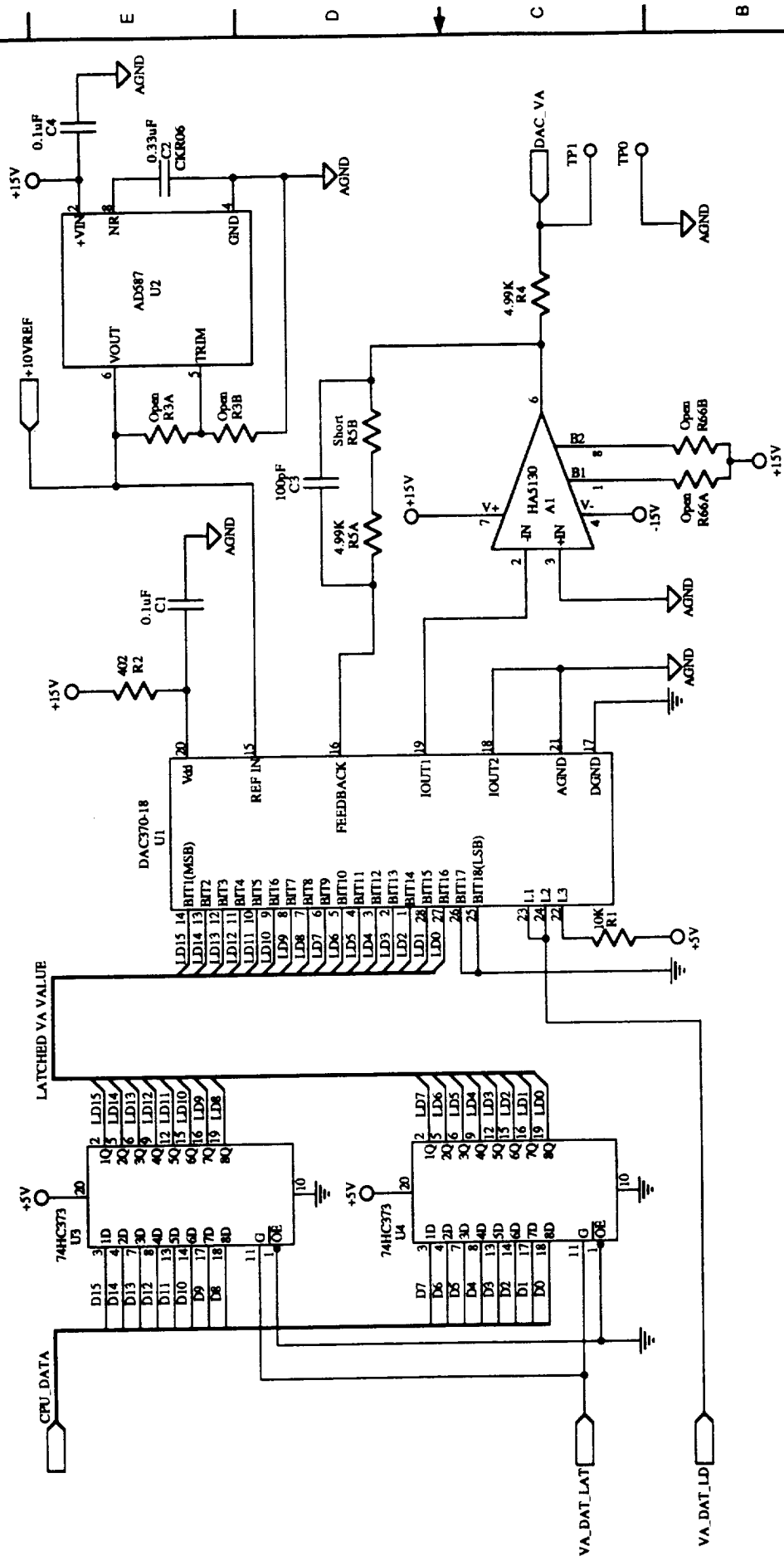


Space Physics Research Laboratory College of Engineering University of Michigan	Connectors Grid Voltage Generator Solar Flux Monitor	REV REV CONTRACT RELEASE DRAWN ENGINEER	Nov 14, 1992
PROJECT NAME SEM/A1/P	FILE NAME PLAN VIEW WORKSHEET		Sept 14, 1991 N. V. Vondra



Space Physics Research Laboratory College of Engineering University of Michigan		Control Logic VA Gen./Electrometer SFM/ALP	REV REV CONTROL RELEASE DRAWN CHECKED ENGINEER	Nov 14, 1991
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## 2.01

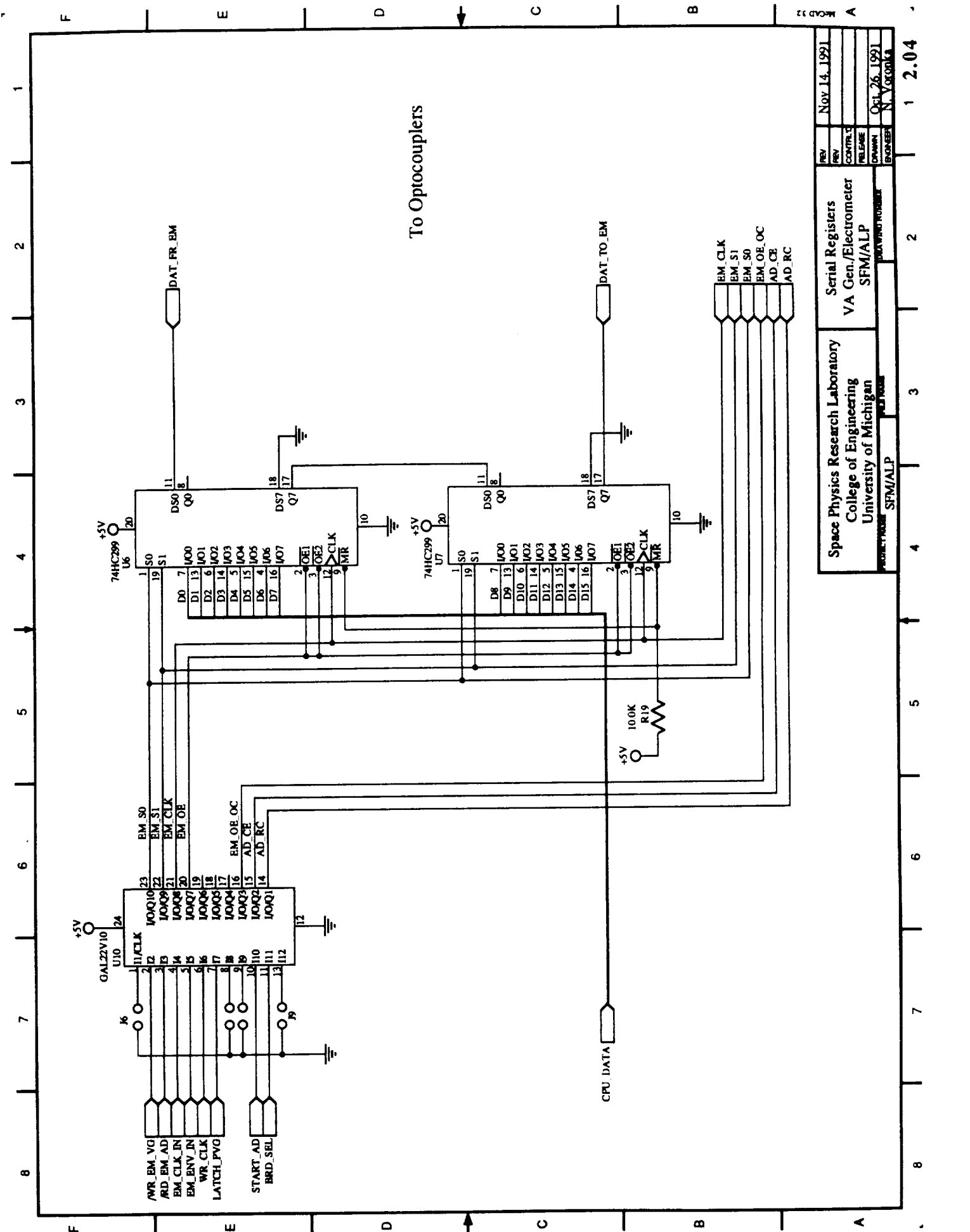


**NOTES:**

1. The total resistance of R3A+R3B must be approximately 10K ohms.
2. The total resistance of R66A+R66B must be approximately 20K ohms.

	4		3		2		1	202
PROJECT FROM SPM/ALP								REV
Space Physics Research Laboratory College of Engineering University of Michigan						VA Generator DAC		Nov 14, 1991
						VA Gen./Electrometer SFM/ALP		
						CONTRACT		
						RELEASE		
						DRAWN		Sep 19, 1991
						EAGLESHAW BLOCK		NOV 14, 1991

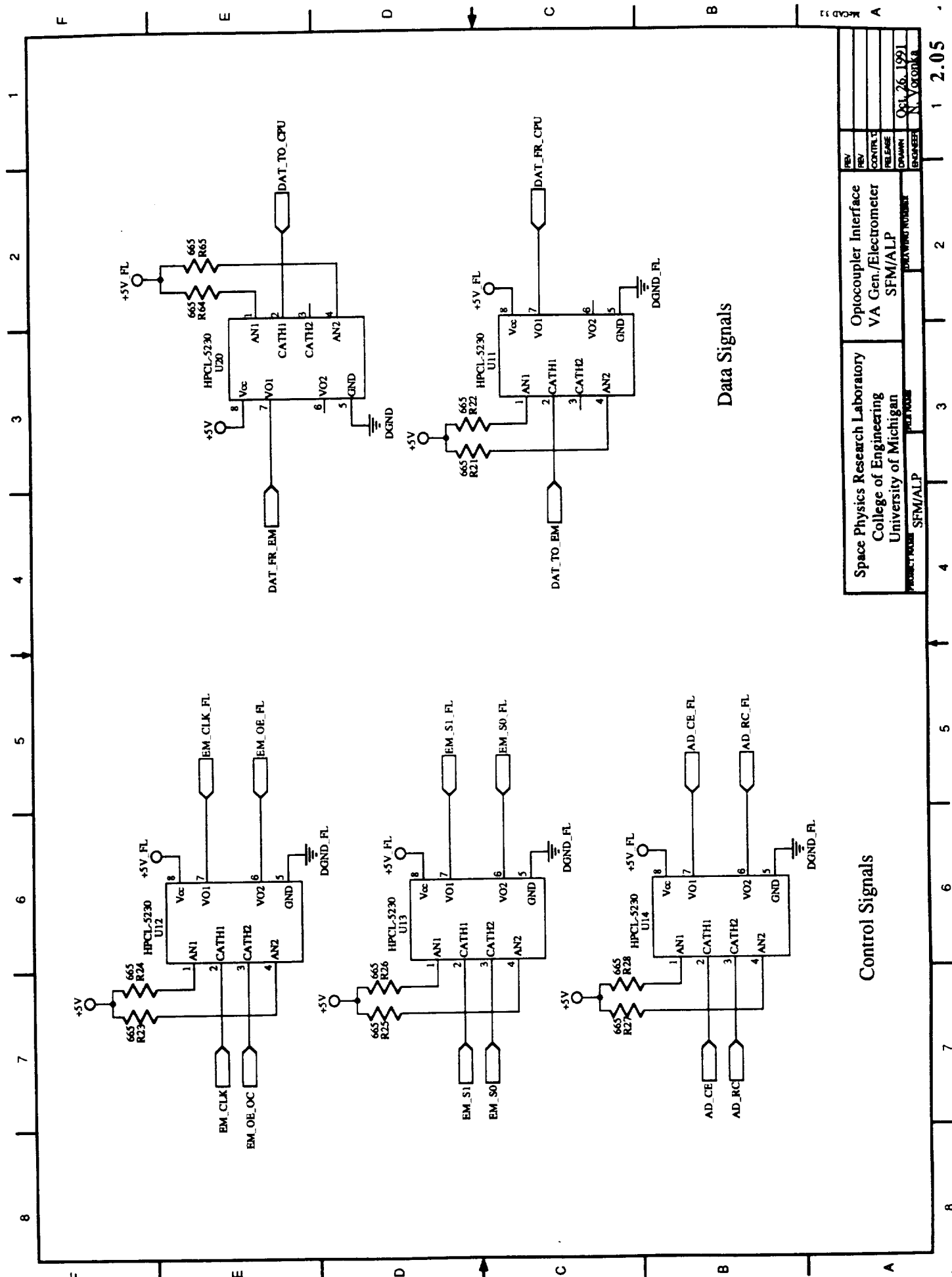




To Optocouplers

REV	Nov 14, 1991
CONTROL	
RELEASE	
DESIGN	QCL 26, 1991
ENGINEER	N. V. VORONKA

PROJECT NUMBER	SFM/ALP
DATE	
DESIGNED BY	
CHECKED BY	
APPROVED BY	
Serial Registers	VA Gen./Electrometer
	SFM/ALP



Data Signals

Control Signals

Space Physics Research Laboratory		Optocoupler Interface	
College of Engineering		VA Gen./Electrometer	
University of Michigan		SFM/ALP	
PROJECT NO.	SFM/ALP	DRAWING NUMBER	
DESIGNED BY	DATE	ENGINEER	
DRAWN BY		RELEASE	
CONTROL			
REV.			
REV.			
Oct 26, 1991		N. V. GONCHAR	

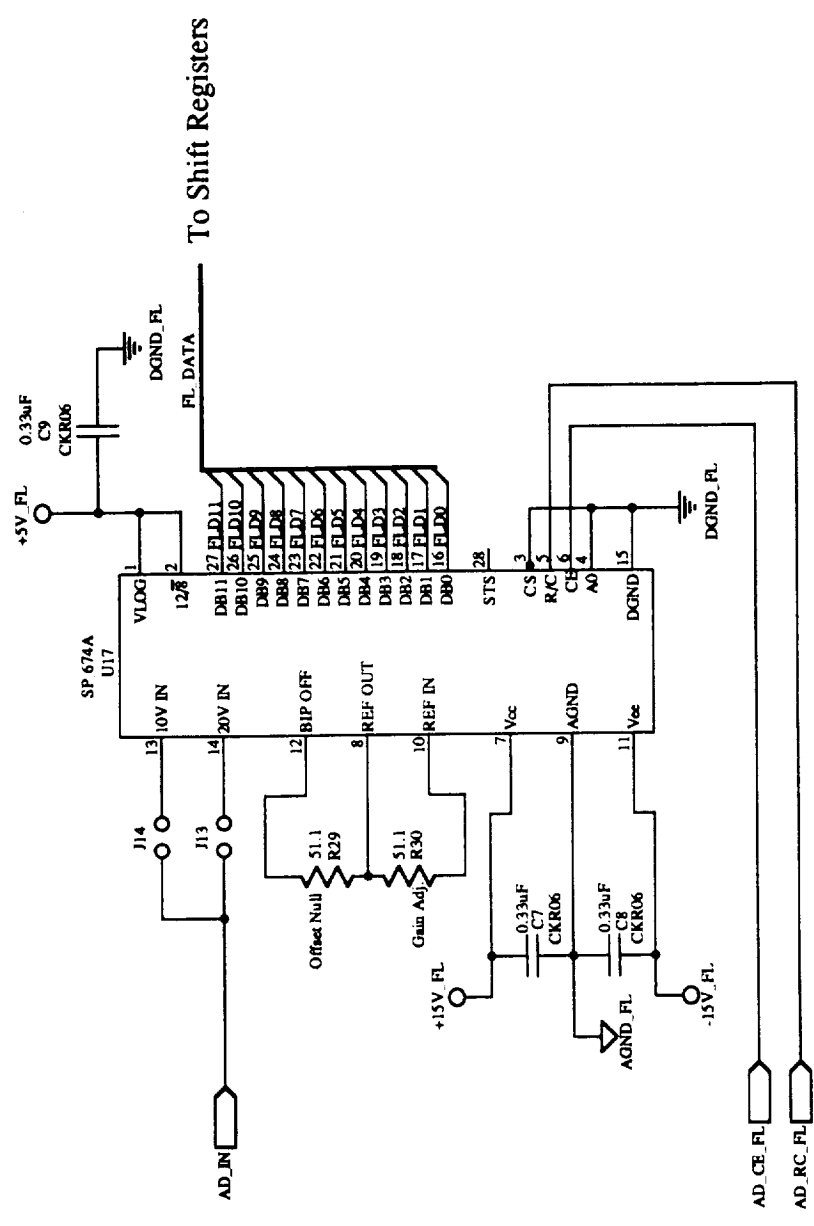


REV	Nov 14, 1991
REV	
CONTROL	
RELEASE	
DRAWN	Oct 11, 1991
ENGINEER	N. V. GONKAR

1 2.07

# A/D Converter

NOTES:  
1. The values of resistors R29 and R30 must not exceed 100 ohms.



Space Physics Research Laboratory  
College of Engineering  
University of Michigan

Electrometer A/D  
VA Gen./Electrometer  
SFM/ALP

REV	Nov 14, 1991
REV	
CONTROL	
RELEASE	
DRAWN	Oct 11, 1991
ENGINEER	N. V. GONKAR

2

3

4

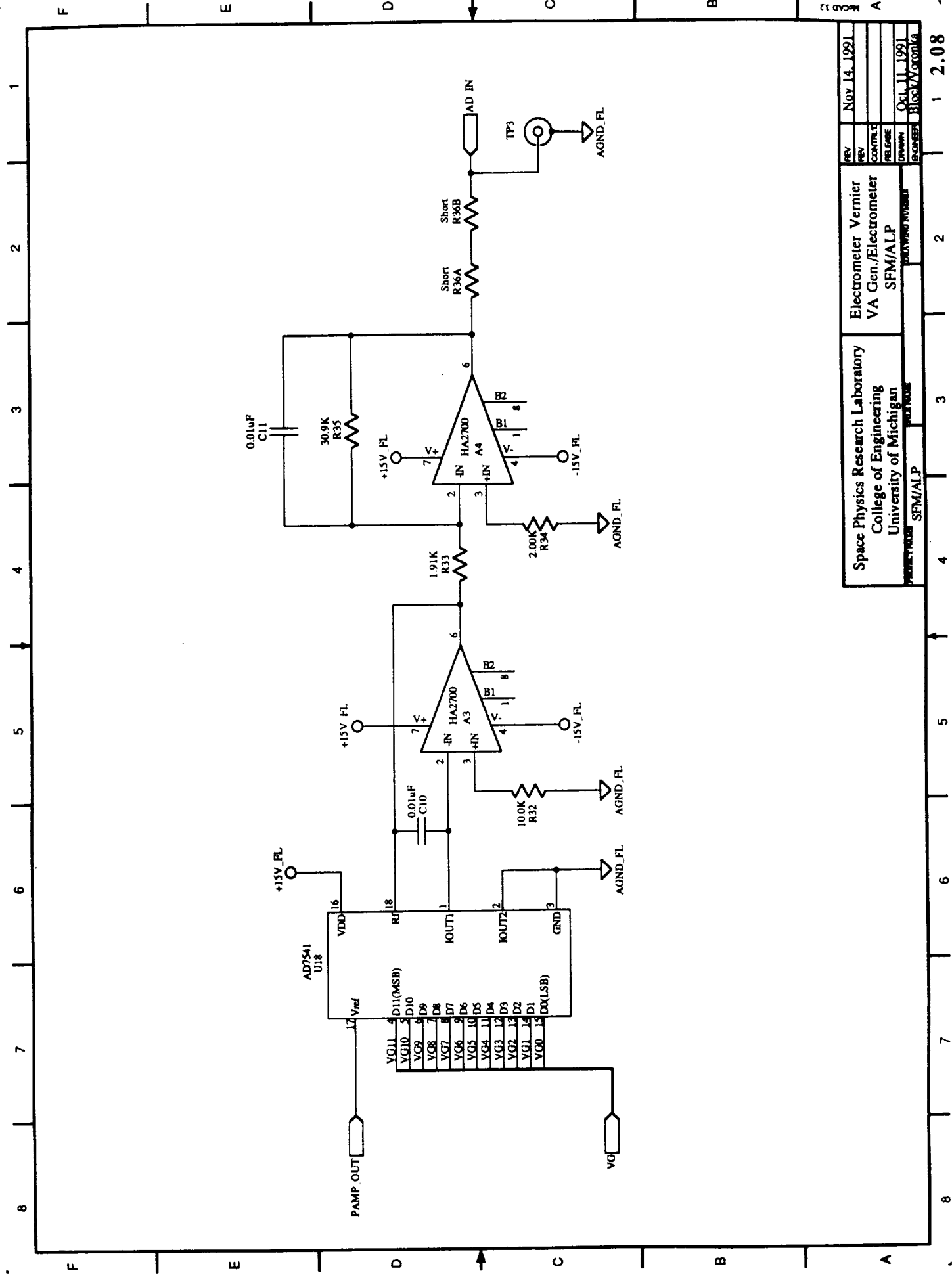
5

6

7

8





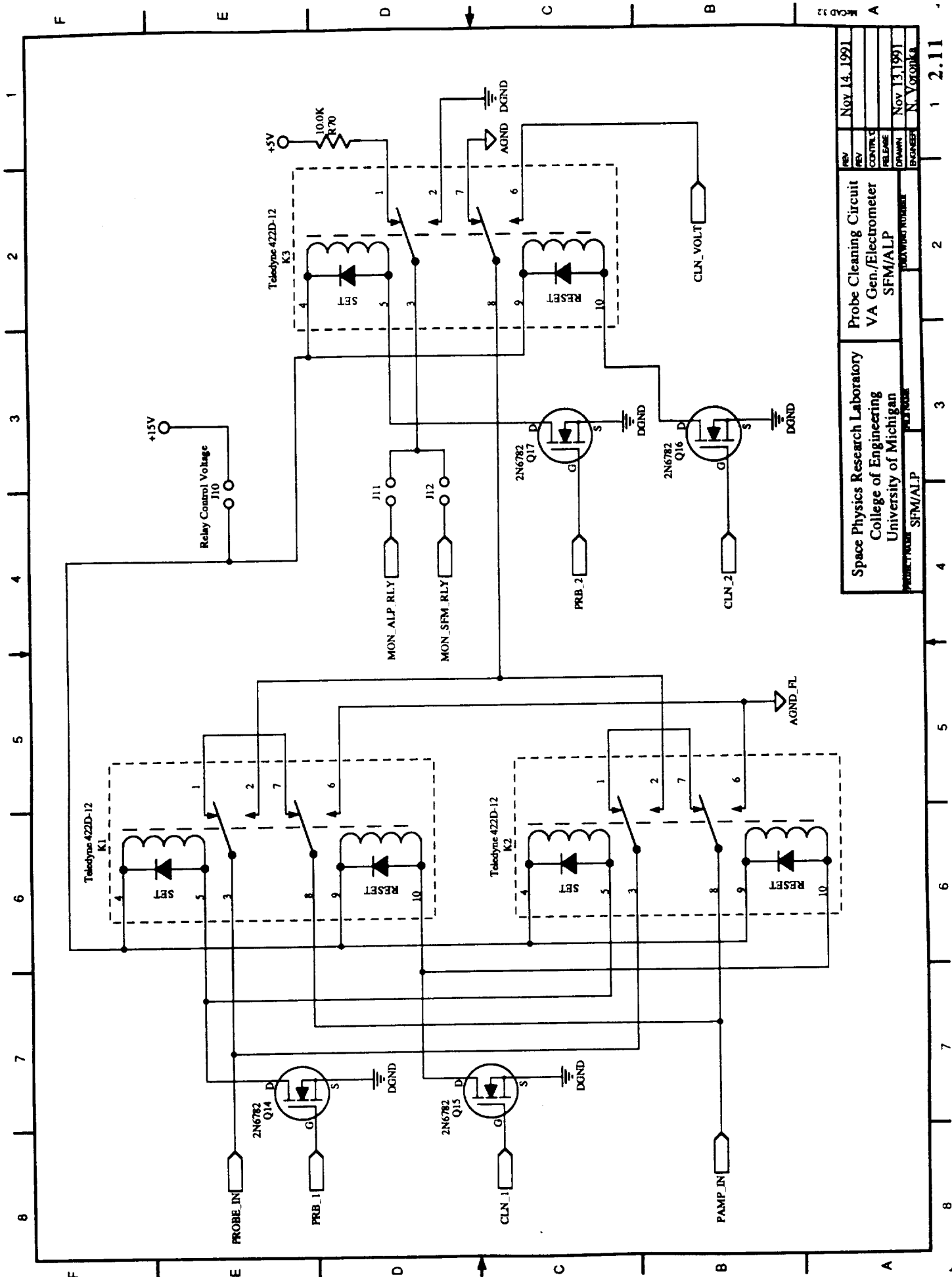
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REV	
CONTROL	
REL	
DRAWN	Oct 11, 1991
DESIGNED	Block 2.08
PROJECT	SFM/ALP
DATE	11/14/91
TIME	11:00
BY	Block 2.08

Space Physics Research Laboratory  
College of Engineering  
University of Michigan

Electrometer Vernier  
VA Gen./Electrometer  
SFM/ALP



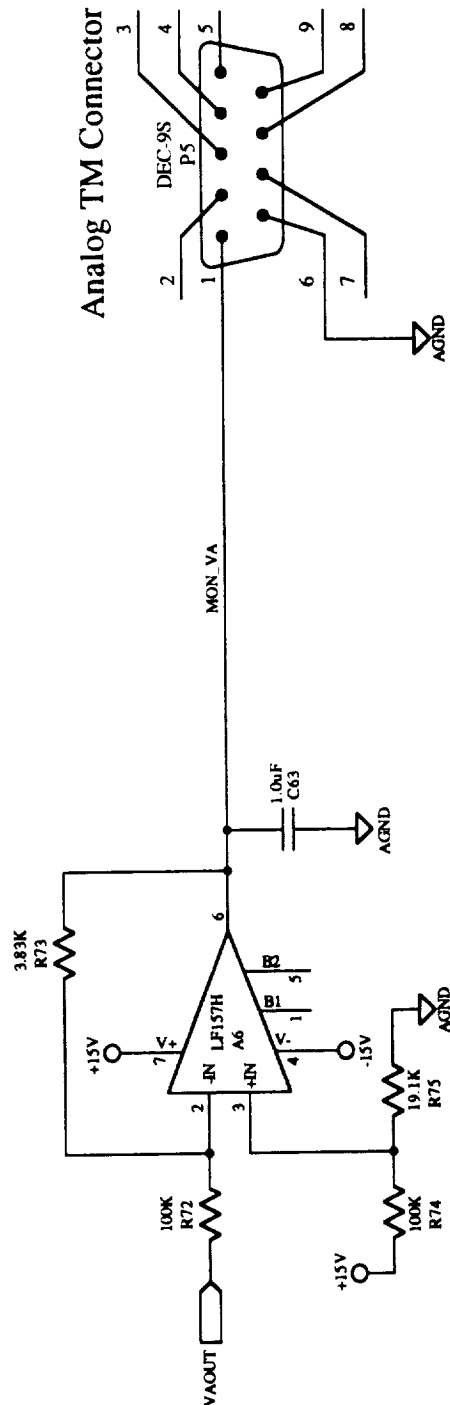




REV	NOV 14 1991
REV	
CONTROL	
RELEASE	NOV 13 1991
DRAWN	N. V. GORDON
ENGINEER	
PROJECT NAME	SFM/ALP
DATA UNIT NUMBER	
PROBE NAME	
LABORATORY	Space Physics Research Laboratory
COLLEGE	College of Engineering
UNIVERSITY	University of Michigan

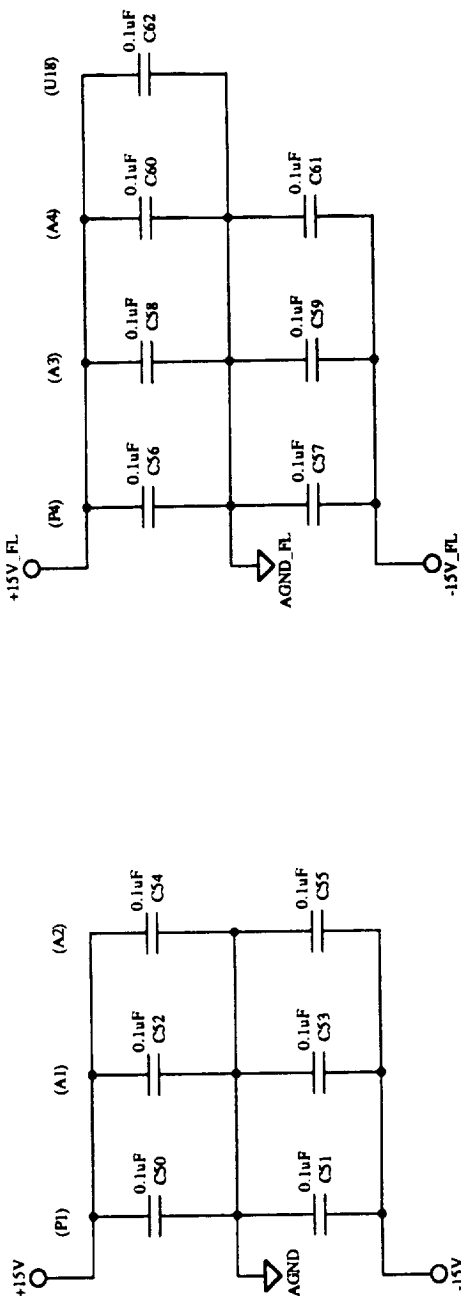
Probe Cleaning Circuit  
VA Gen/Electrometer  
SFM/ALP

# Analog TM Connector



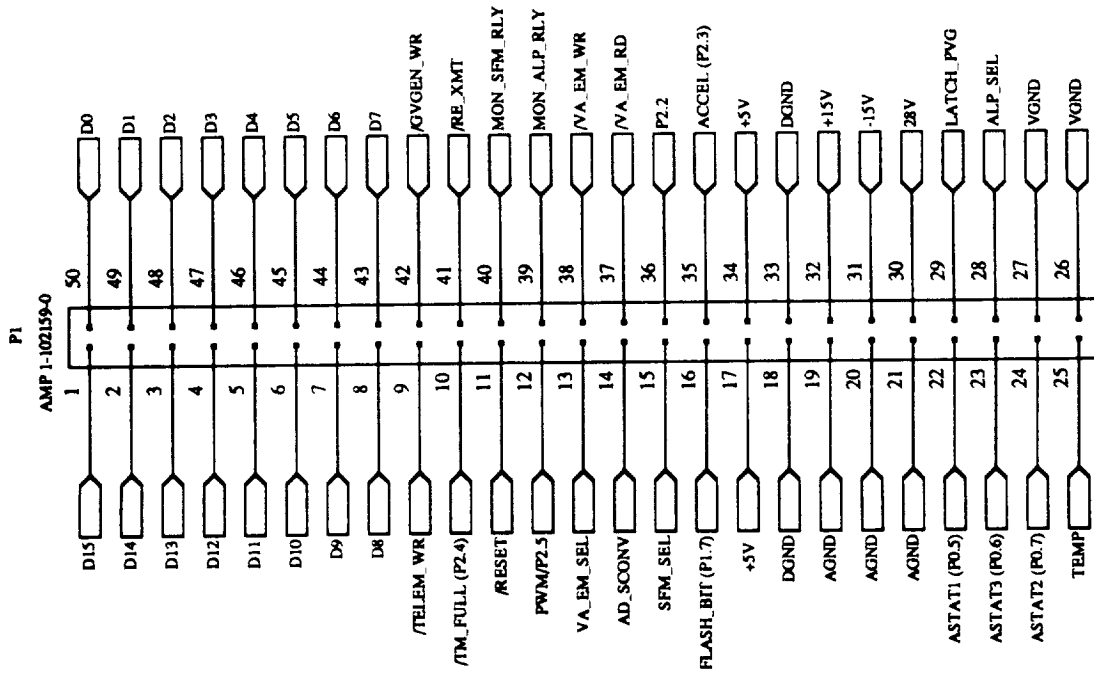
Space Physics Research Laboratory		Voltage Monitor Buffers		REV	Nov 14, 1991
College of Engineering		V A Gen./Electrometer		REV	
University of Michigan		Solar Flux Monitor		CONTROL	
PROJECT NAME SFM/ALP		DRAWING NUMBER		RELEASE	
FILE NAME		FILE NAME		DRAWN	Feb 19, 1992
				ENGINEER	N. V. GONKA

12.12

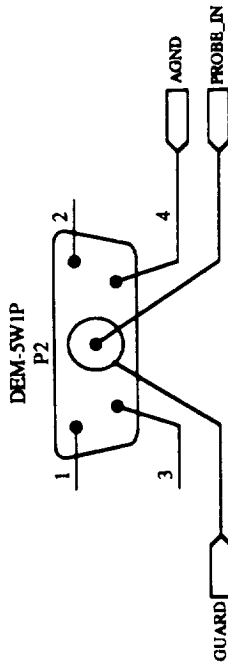


Space Physics Research Laboratory College of Engineering University of Michigan	Power Supply Filters VA Gen./Electrometer Solar Flux Monitor	REV/ REV/ CONTROL FELINE DRAWN Feb 20, 1991
PROJECT NUMBER SPM/ALP	DRAWING NUMBER	N. V. or ON VA

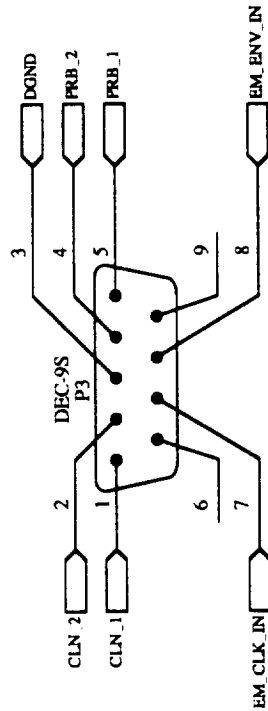
# System Connector



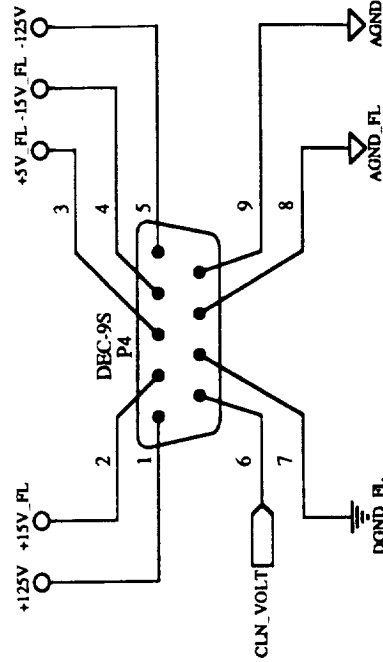
# Sensor Connector



# Relay Control & Shift Clock Connector

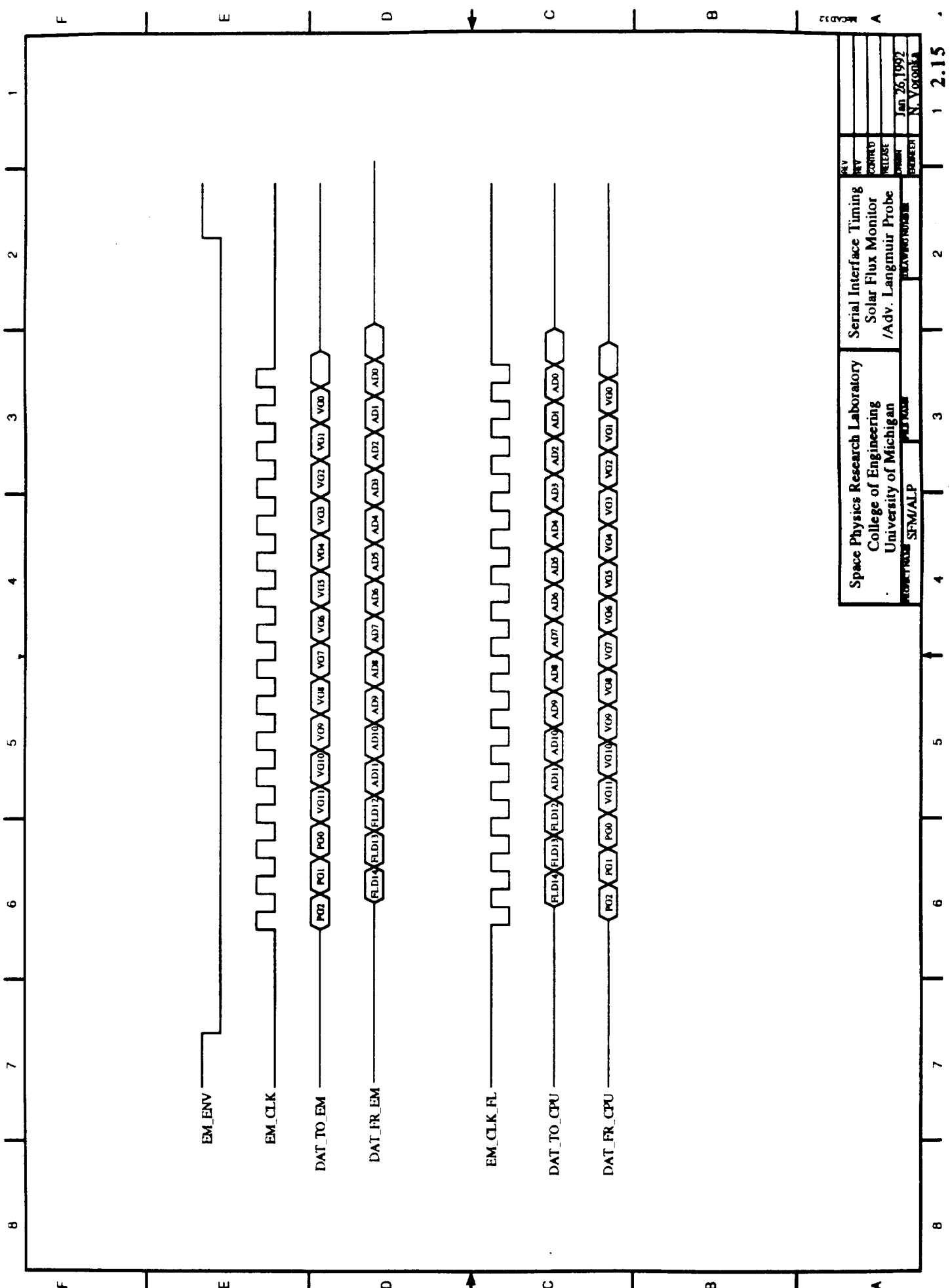


# Power Supply Connector



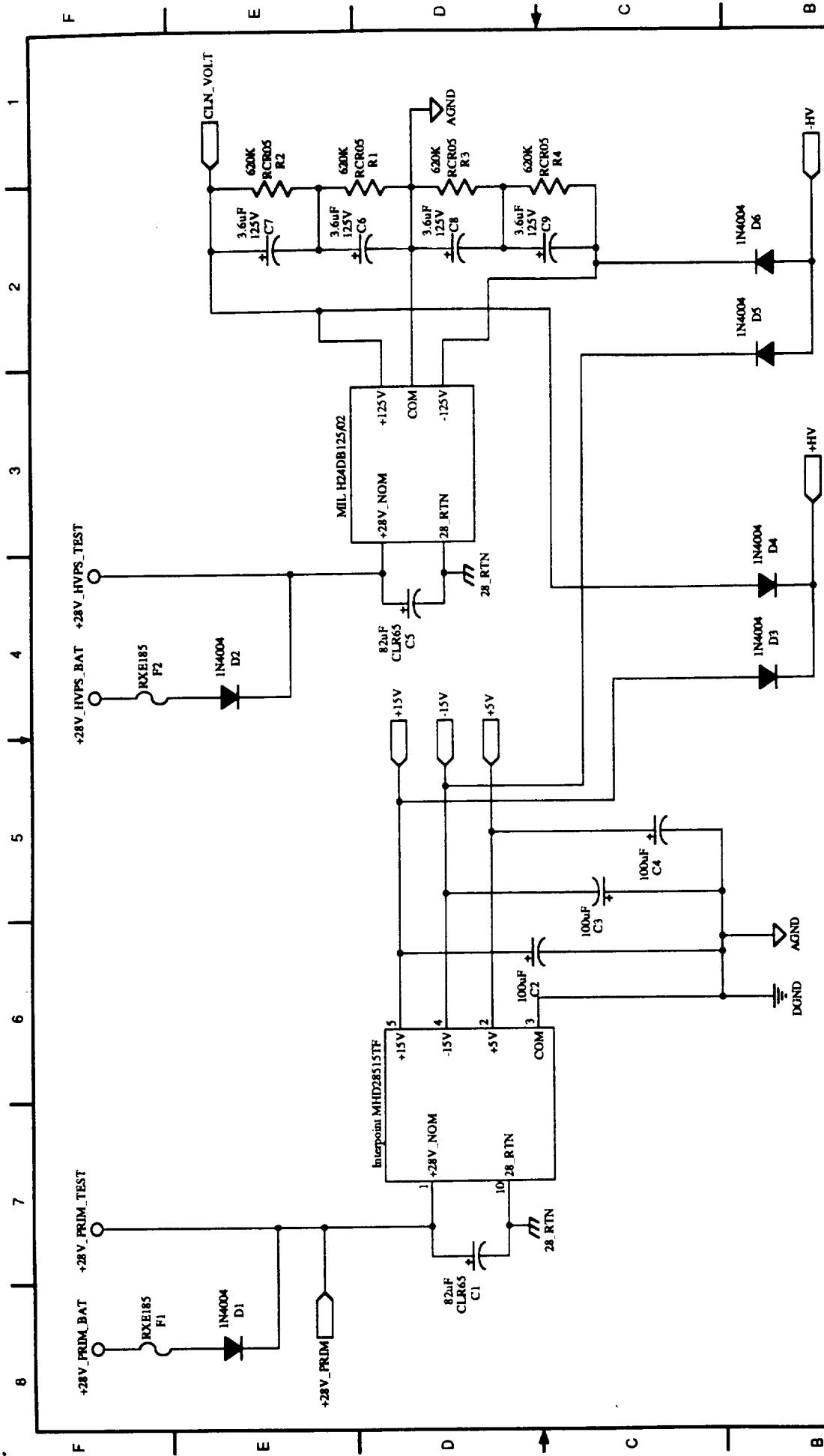
NOTES:  
1. A jumper must be installed between pin 3 of P2 (GUARD) and pin 8 of P4 (AGND\_FL).

PROJECT NAME	SFM/ALP	DATE	1 2.14
DESIGNED BY	VA Gen/Electrometer	ENGINEER	N. V. Gorka
CHECKED BY	SFM/ALP	DESIGNED BY	N. V. Gorka
APPROVED BY	VA Gen/Electrometer	CONTROL	
RELEASE		DATE	Sept 14, 1991



Serial Interface Timing		REV	
Solar Flux Monitor		REV	
/Adv. Langmuir Probe		CONTRD	
		RELEASE	
		DATE	Jan 26, 1992
		DESIGNED	N. Votaw
		REVIEWED	
		APPROVED	
		PROJECT NO.	SFM/ALP
		FILE NO.	





NOTES:

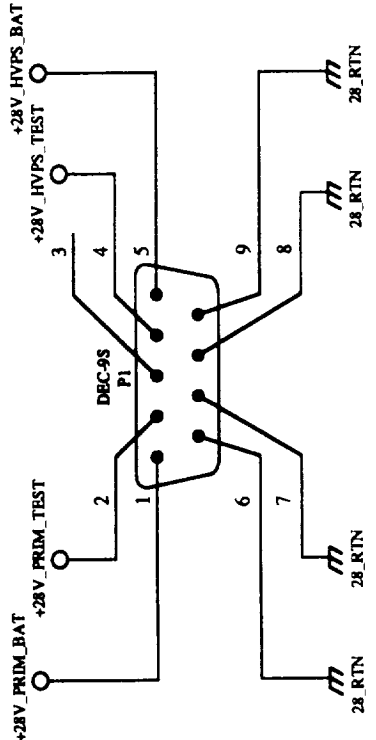
1. Devices F1 and F2 are PolySwitch current limiting devices. They were required by NASA/WFF for the 27.133 rocket flight experiment. They will sustain a maximum of 1.85 amperes without tripping.

PROJECT NUMBER		REV		DATE	
SFPM/ALP		REV		Nov 14, 1991	
DESIGNED BY		REV			
CHECKED BY		CONTROL			
DRAWN BY		RELEASE		Mar 5, 1992	
N. V. Gorka		PROJECT NAME		Primary & HV Converters	
		DRAWING NUMBER		Solar Flux Monitor	
				/Adv. Langmuir Probe	

1 3.1

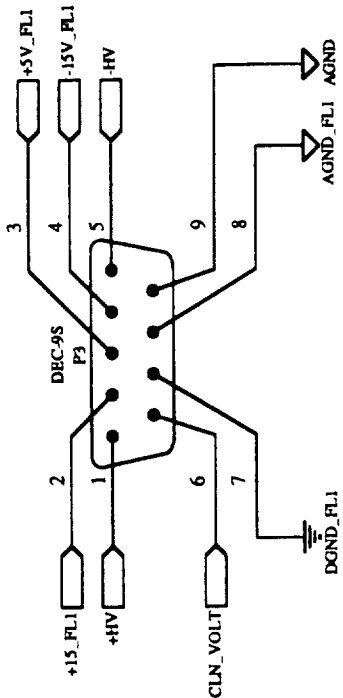


# Primary Power Connector (to SC)



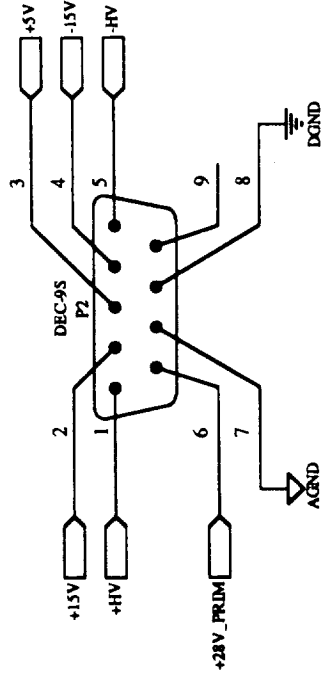
# Power Supply Connector

ALP VA Gen./Electrometer



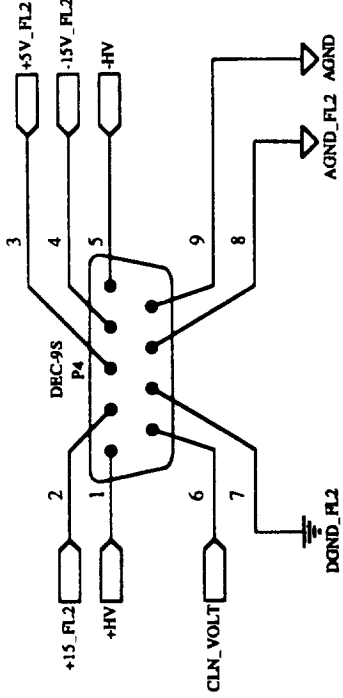
# Power Supply Connector

Grid Voltage Generator

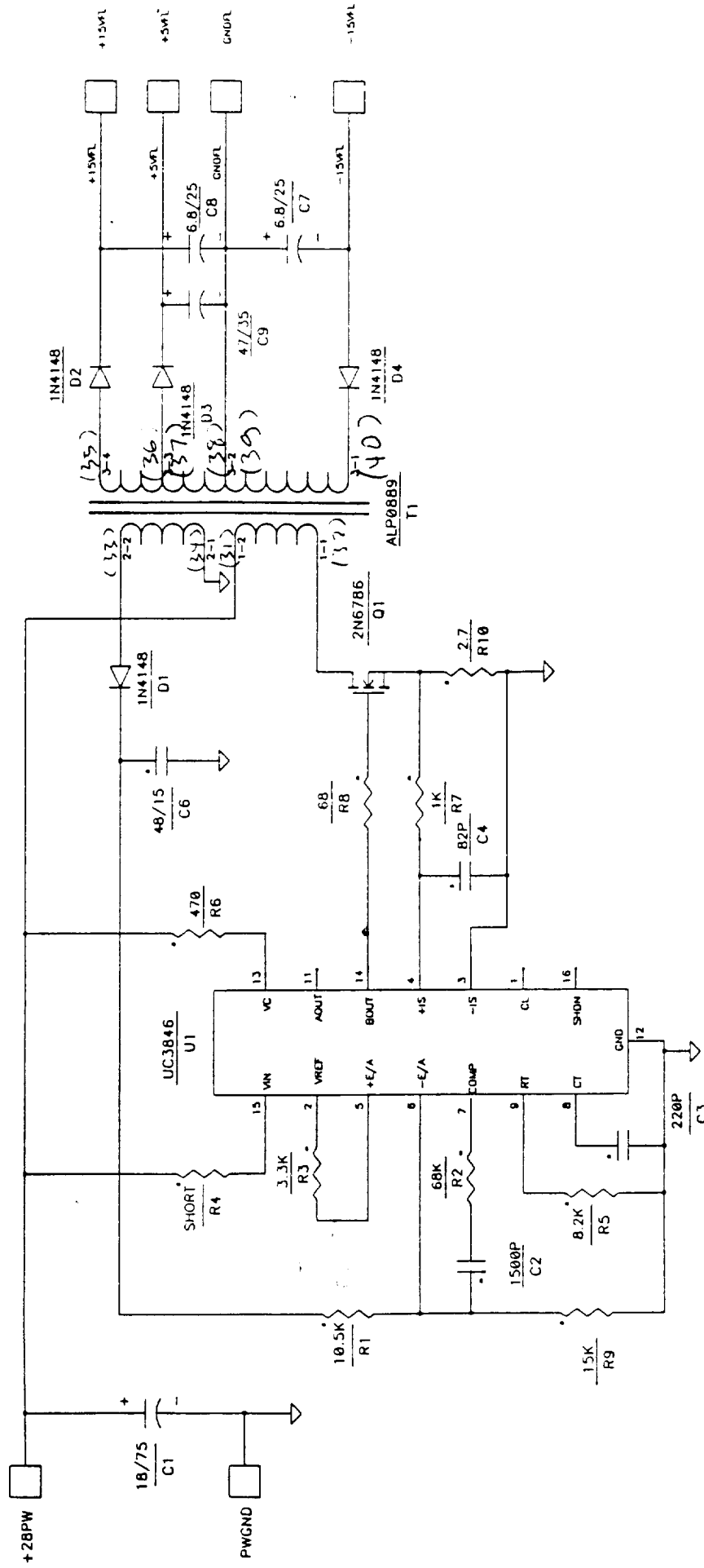


# Power Supply Connector

SFM VA Gen./Electrometer



PROJECT NAME	SFM/ALP	DATE	1/9/92
DESIGNED BY	N. V. GONKAR	REVIEWED BY	
RELEASED BY		CONTROLLED BY	
DATE	Jan 9 1992	REVISION	
DESCRIPTION	Power Supply Connectors Solar Flux Monitor /Adv. Langmuir Probe		



ENGINEER	BLOCK	DRAFTSMAN	8/26/89
SPACE PHYSICS RESEARCH LABORATORY		+/-15, +5 POWER SUPPLY	
COLLEGE OF ENGINEERING		CURRENT-MODE TECHNOLOGY	
UNIVERSITY OF MICHIGAN		CRAF-NGIMS/ALP	
ANN ARBOR, MICHIGAN		B-E8574	
LAST USED R - C - D - I		DATE	

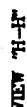
## **APPENDIX C**

### **SEUV/ALP Mechanical Drawings**

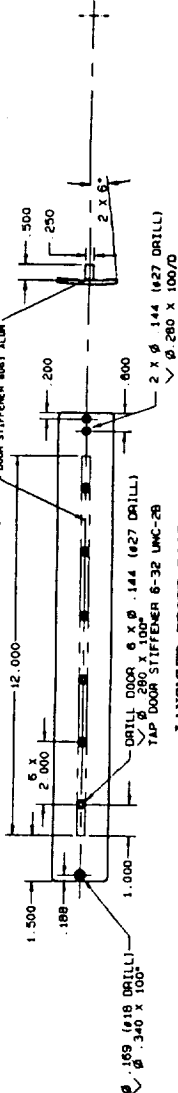




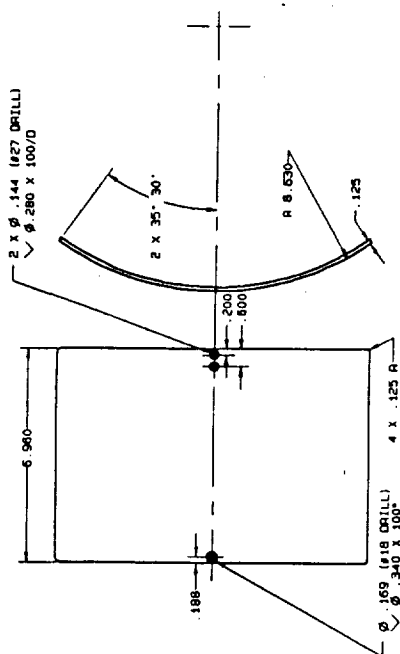
**VIEW "D-D"**  
**SOLAR FLUX MONITOR DOOR CUTOUT**



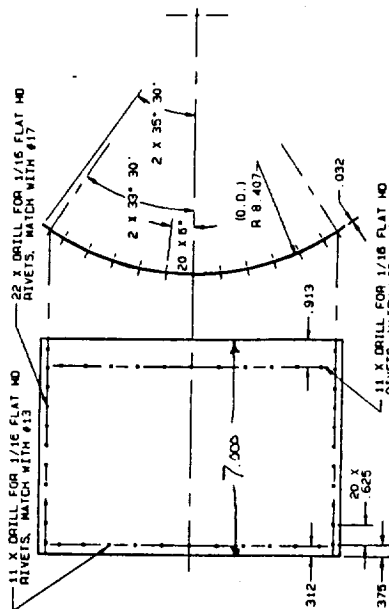
VIEW "E-E"  
LANGMUIR PROBE DOOR CUTOUT



LANGMUIR PROBE DOOR  
8061-T6 ALUMINUM, 1 REQ

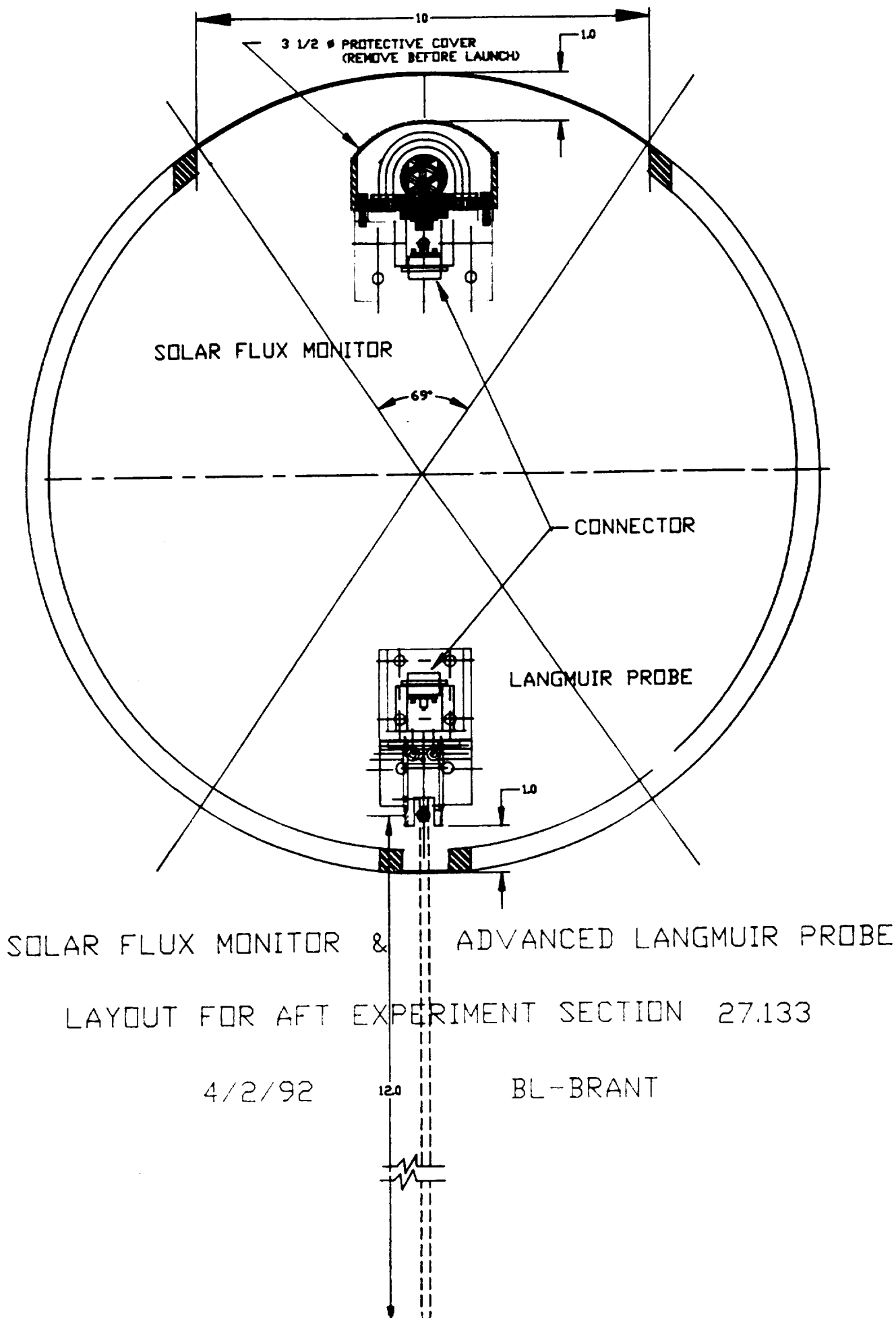


① SOLAR FLUX MONITOR EJECTABLE DOOR  
6061-T6 ALUMINUM, 1 REQ.  
NOTE: MACHINE TO FIT DOOR CUTOUT  
SHOWN IN VIEW "D-D" WITH .020 CLEARANCE

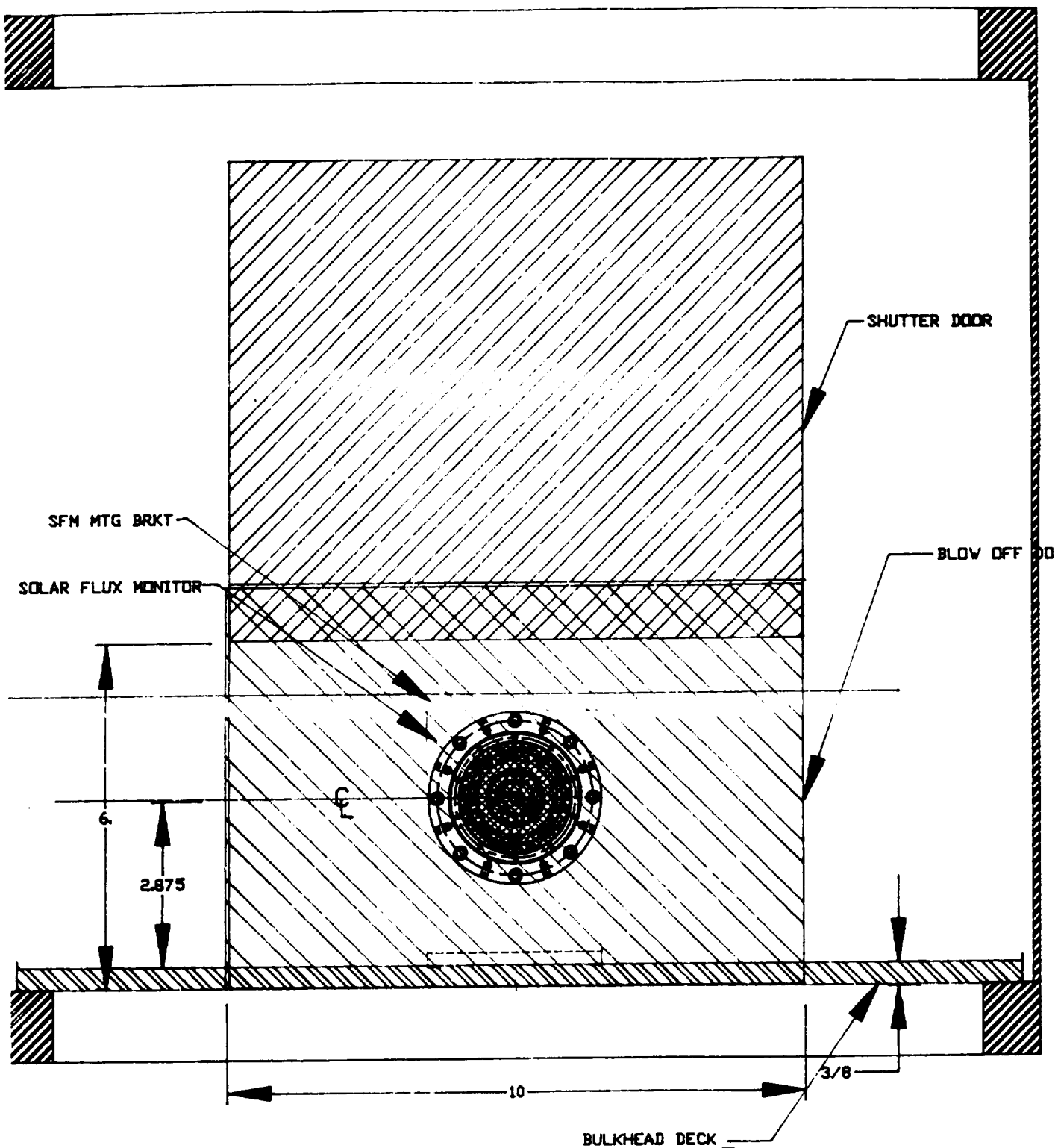


① SOLAR FLUX MONITOR SLIDING DOOR  
STAINLESS STEEL, 1 REQ.

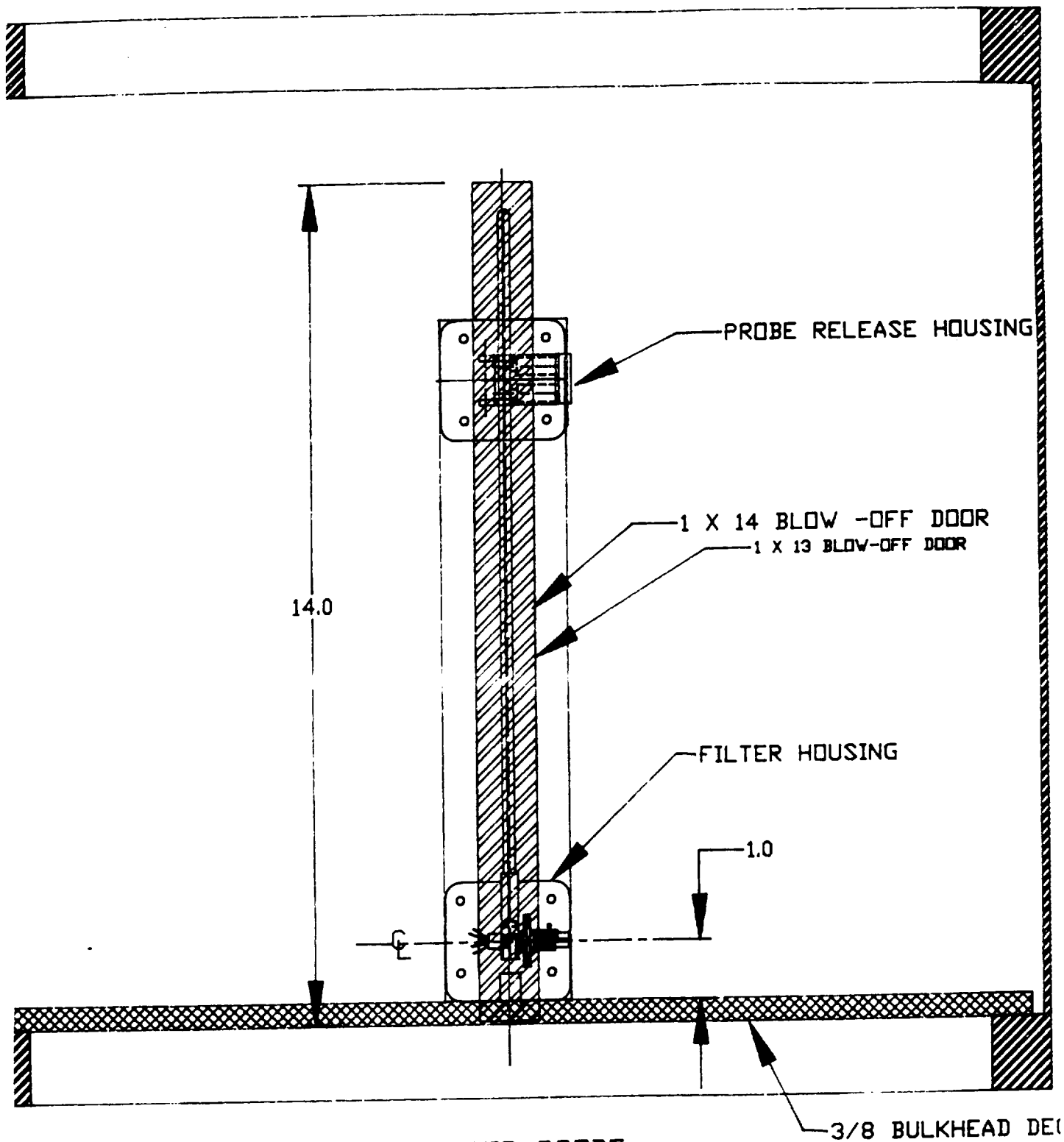
[illegible]





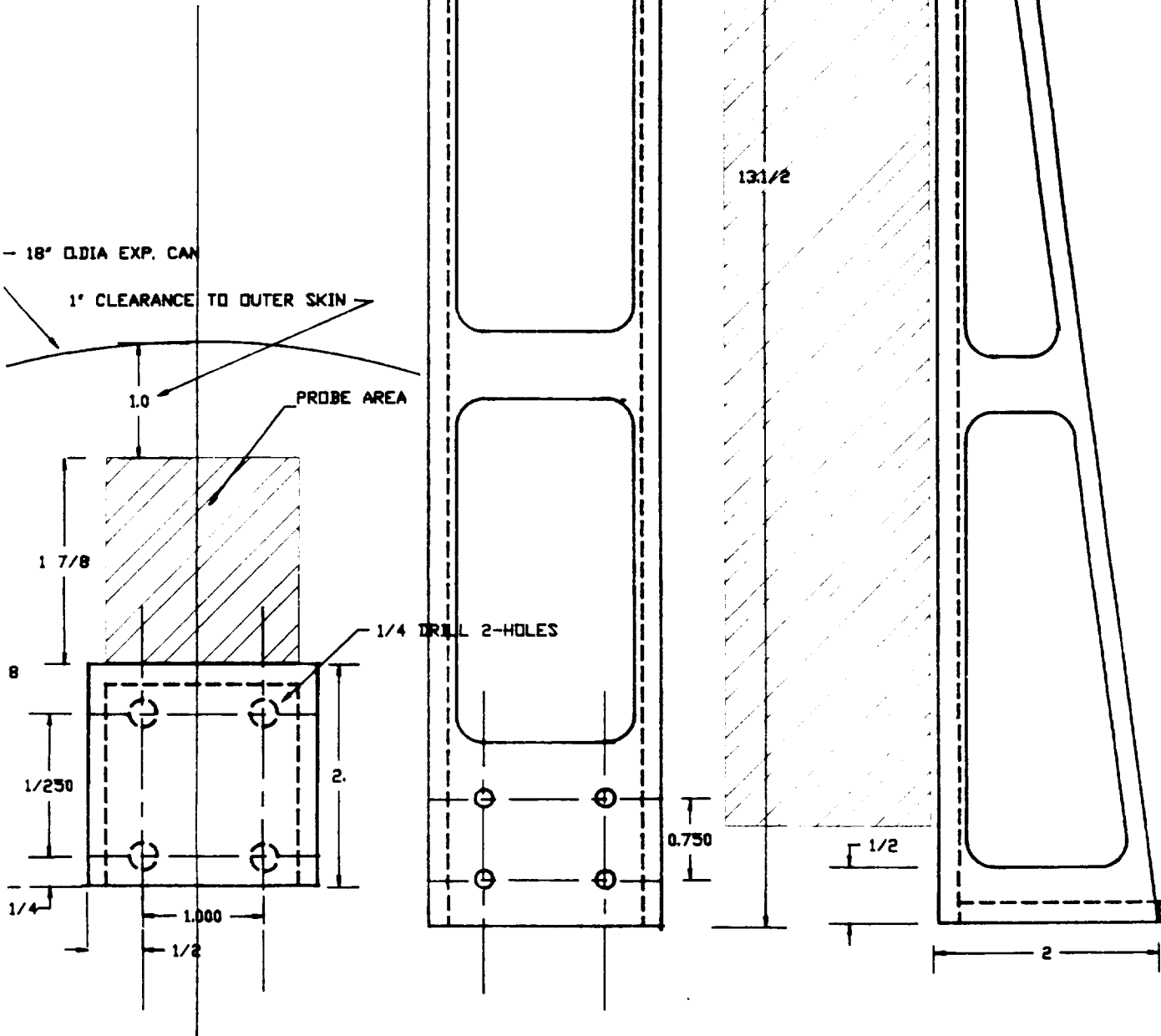


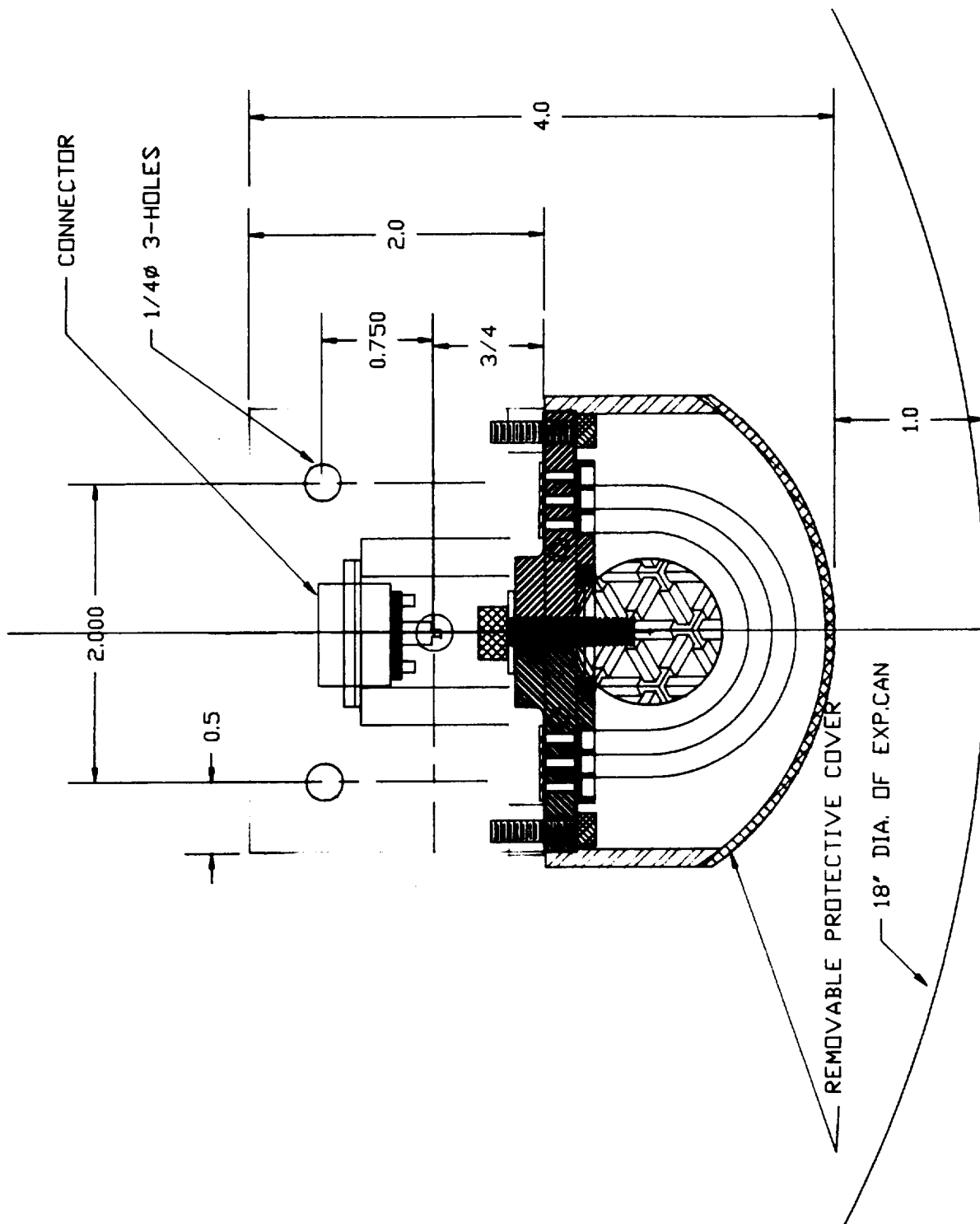
SOLAR FLUX MONITOR  
 LAYOUT FOR AFT EXPERIMENT SECTION



LANGMUIR PROBE  
LAYOUT FOR AFT EXPERIMENT SECTION

PROBE SUPPORT  
INSTALLATION DRAWING  
GC-1527755





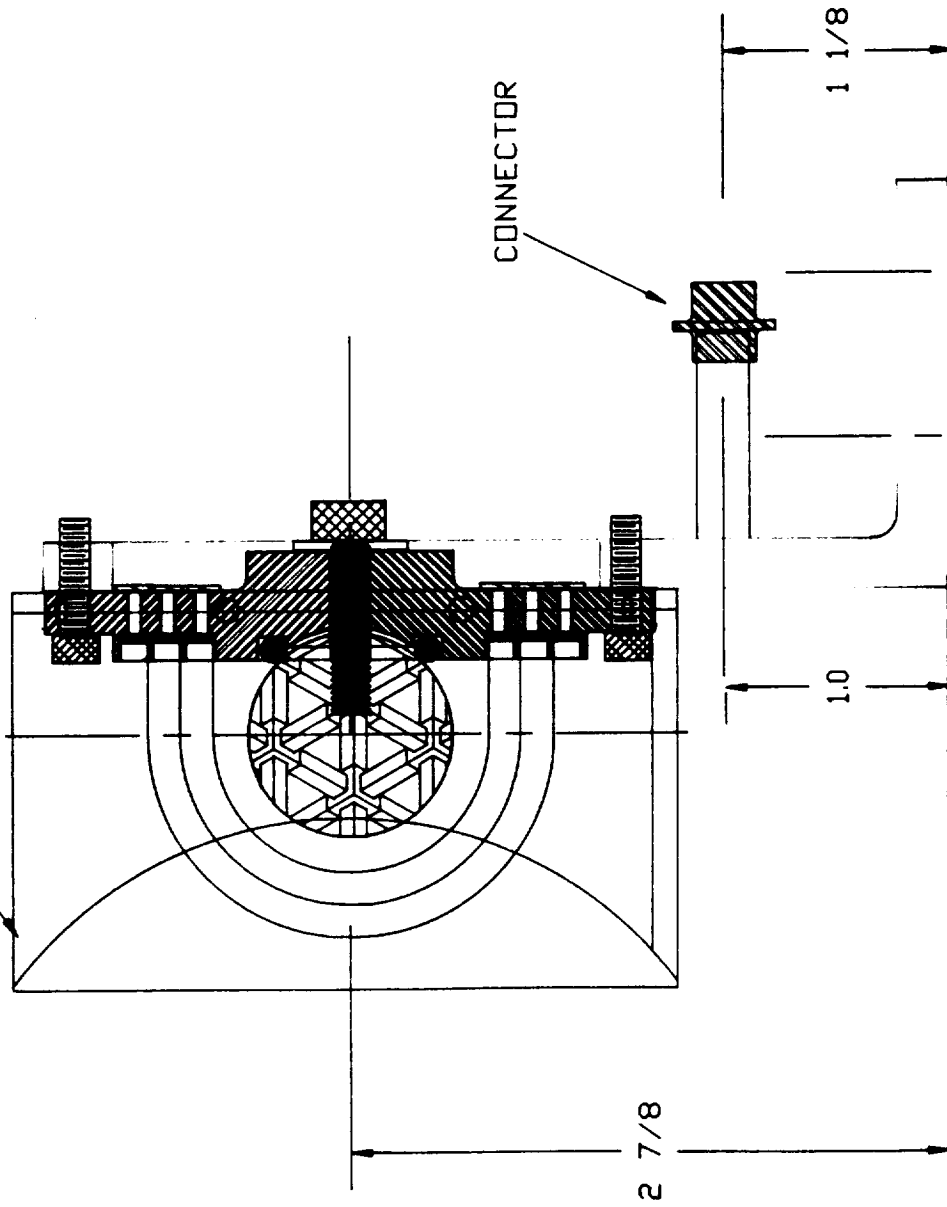
SOLAR FLUX MONITOR  
INSTALLATION DRAWING

TOP VIEW

3/26/92

EUV-7701

REMOVABLE PROTECTIVE COVER

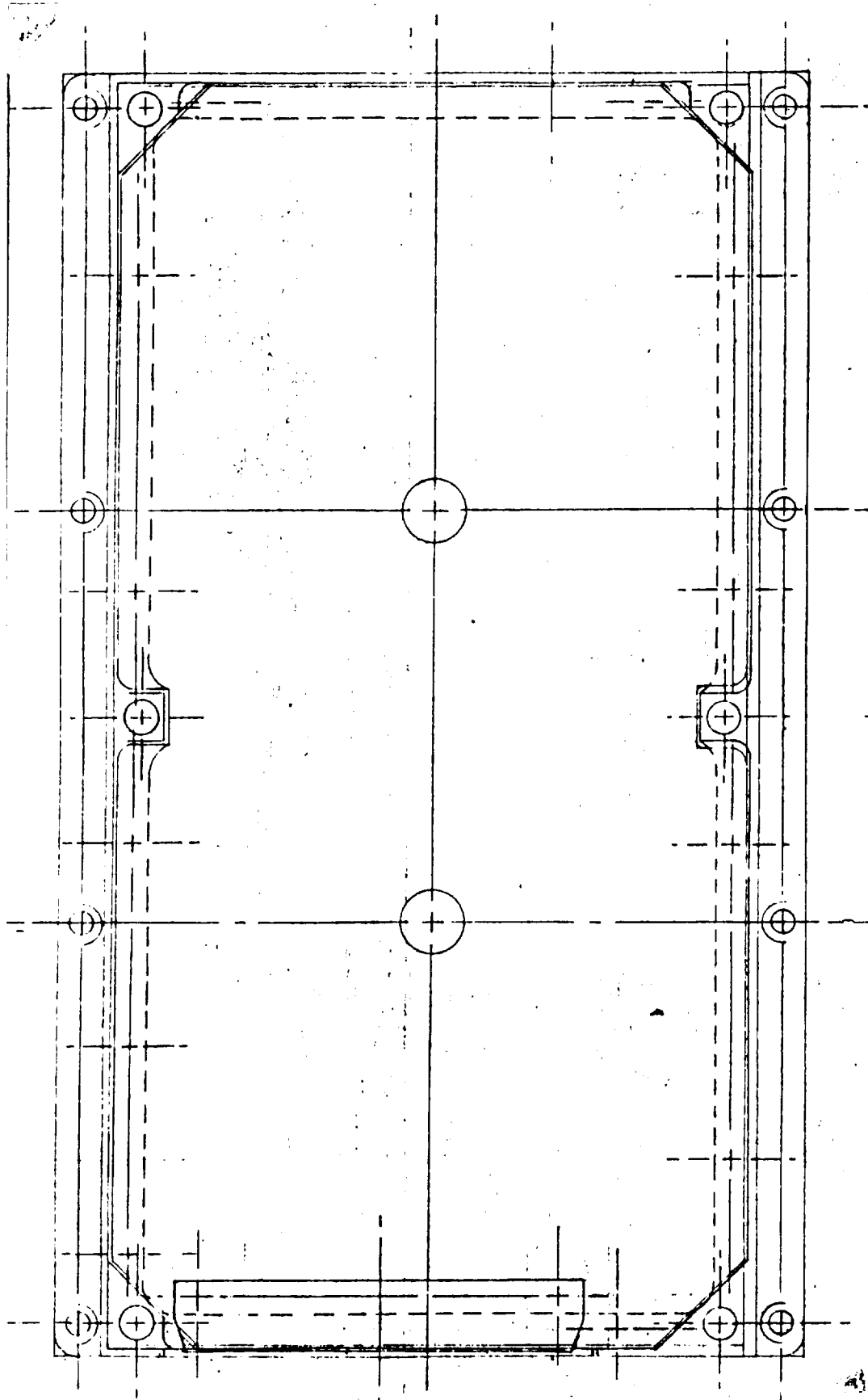


SOLAR FLUX MONITOR  
INSTALLATION DRAWING

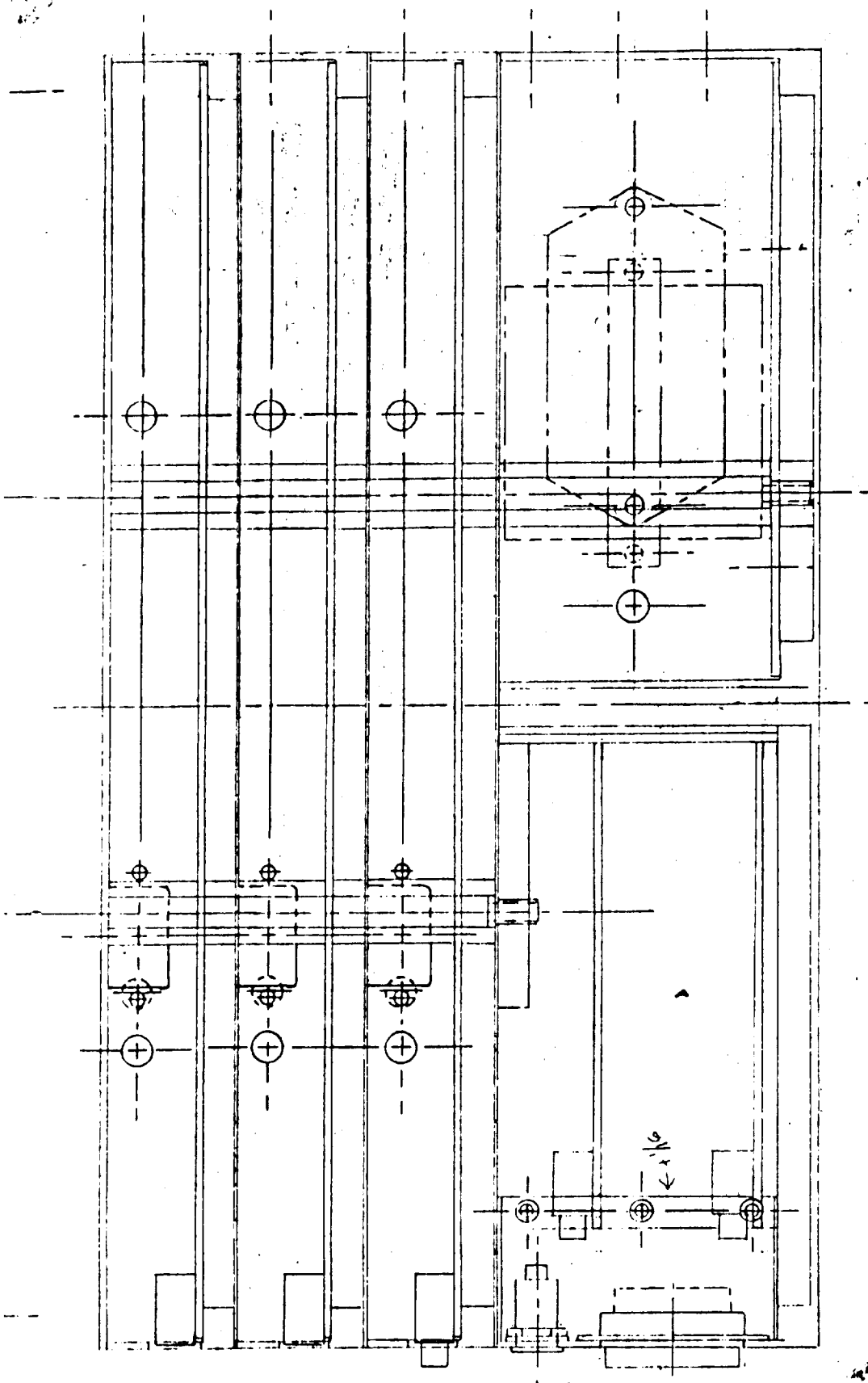
EUV-7701

3/26/92

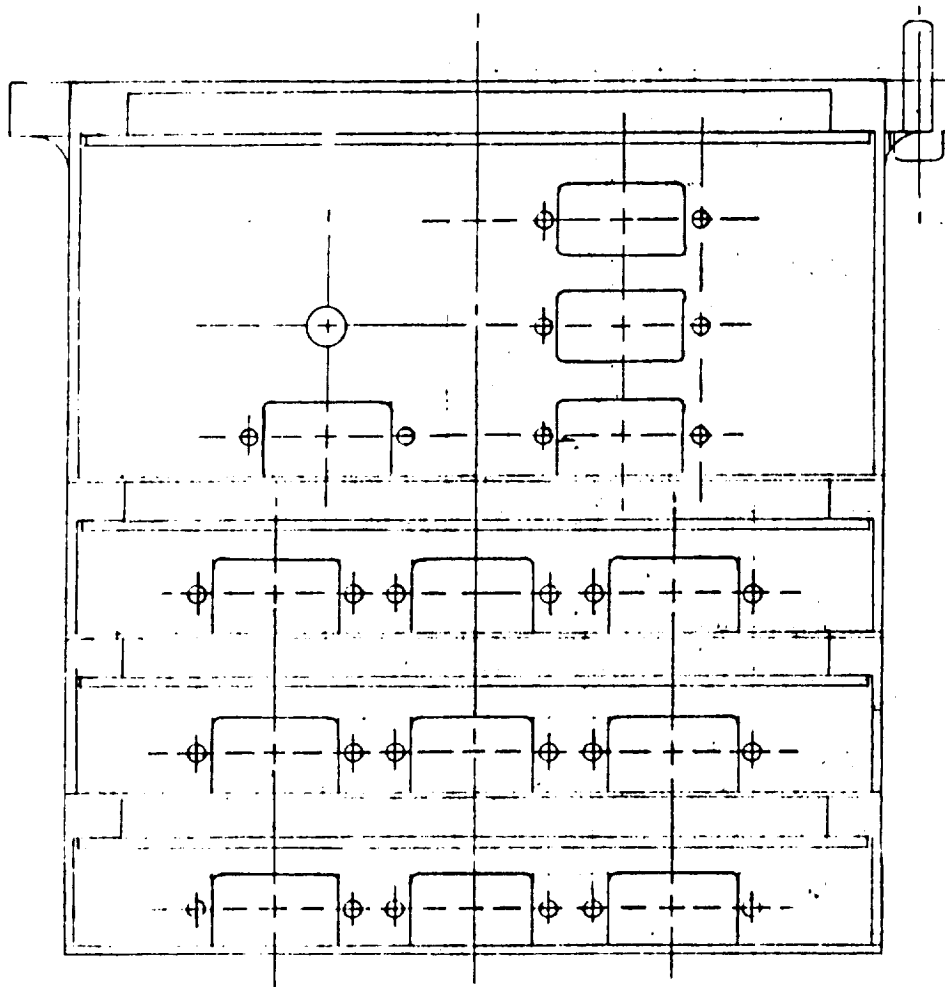
SIDE VIEW



D-048-001 PLAN

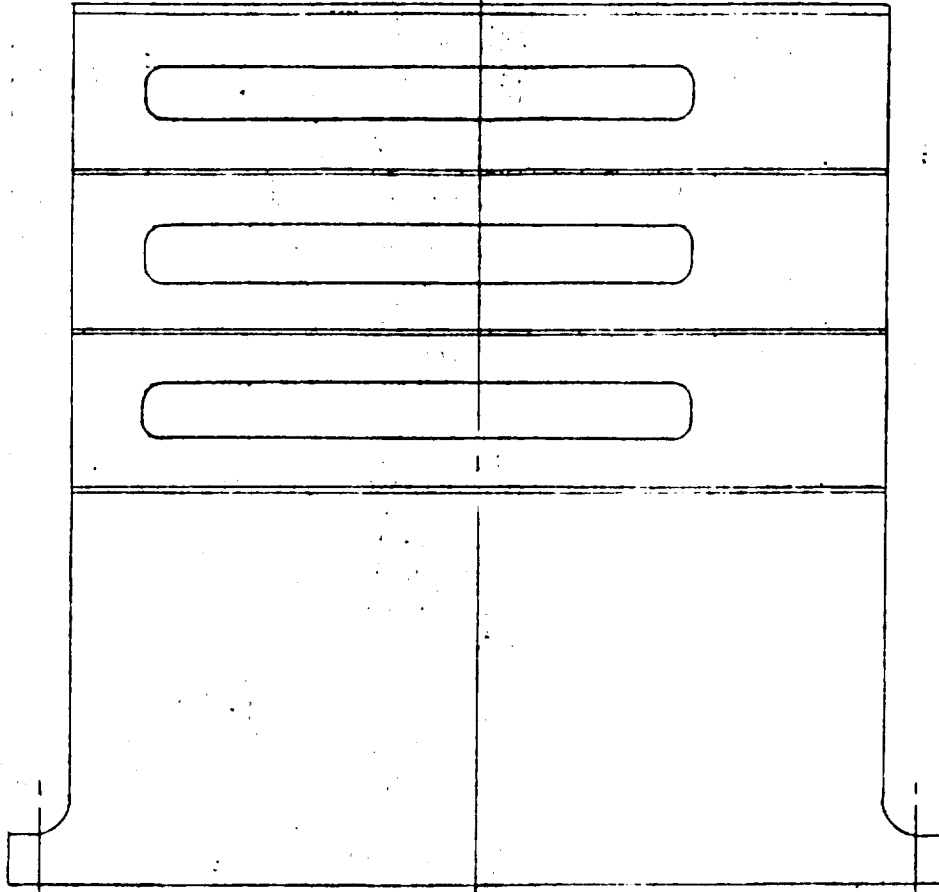


D-048-001 FRONT



D-048-001 R.SIDE





D-048-001 L. SIDE



ZONE		LTR		REVISION		DESCRIPTION		OFTMN		DATE		APPROVED	

3/8-24 NF-2 TAP THRU

250

500 DIA

438 CENT. FLAT

3

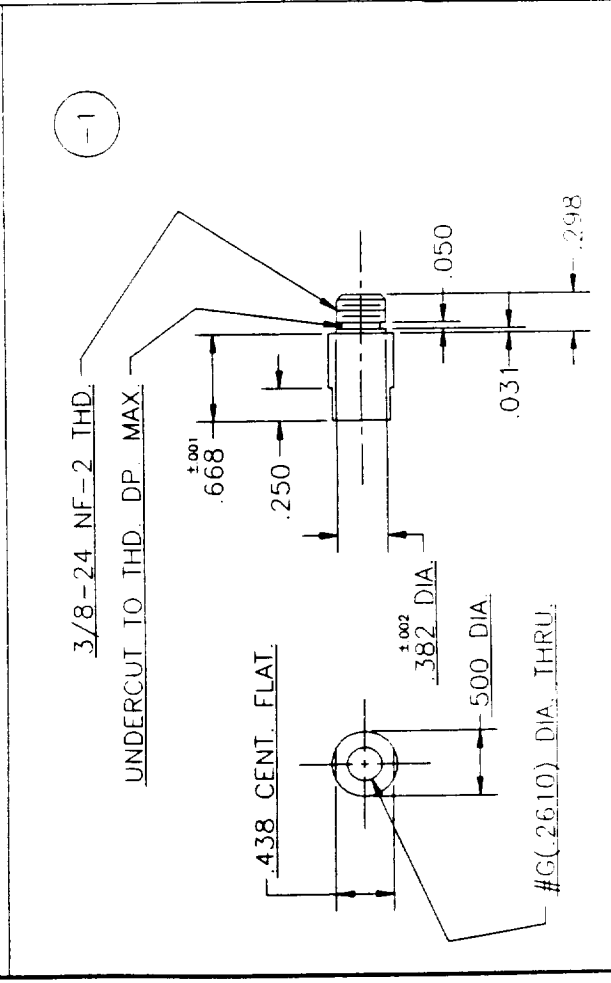
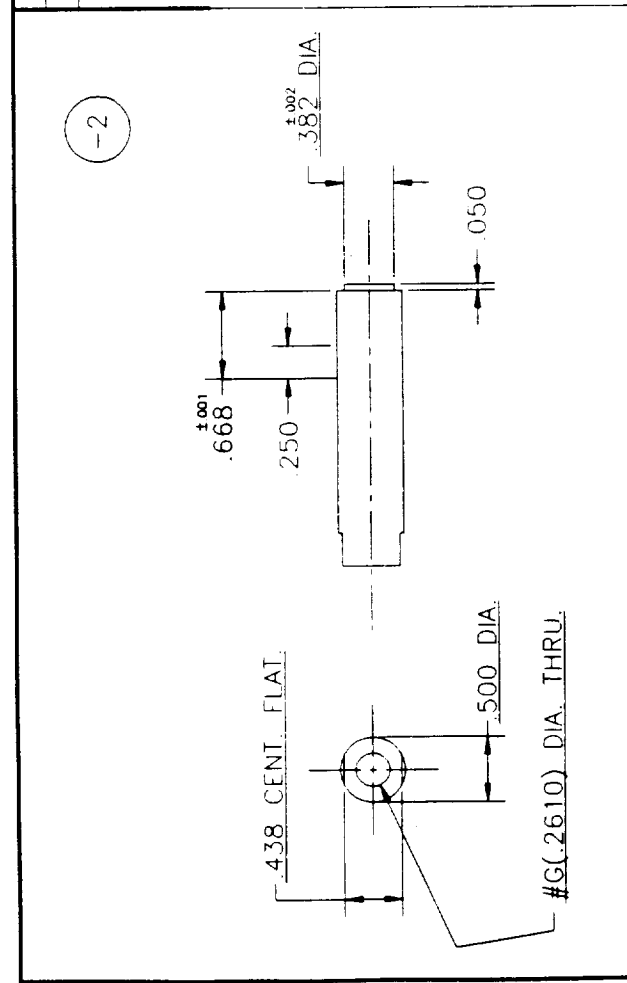
L. H.	R. H.	PART NO.	L. H.	R. H.	NO. REQD.	NAME	DESCRIPTION
6			-3			NUT	500 DIA x 250 6061-T651 AL
1			-2			LONG SPACER	500 DIA x 2.155 6061-T651 AL
6			-1			SHORT SPACER	500 DIA x .966 6061-T651 AL

DESIGNED BY BJC		APPROVED BY	
DRAWN BY DDJ		SCALE FULL SIZE	
CHECKED BY		DATE 5-13-92	
SPACE PHYSICS RESEARCH LABORATORY			
COLLEGE OF ENGINEERING			
THE UNIVERSITY OF MICHIGAN			
ANN ARBOR, MICHIGAN			
DECK SPACERS-POSTS & NUTS			
ELECTRONIC HOUSING ASS'Y			
FLIGHT SMF /ALP			
DWG. NO. B-048-003			

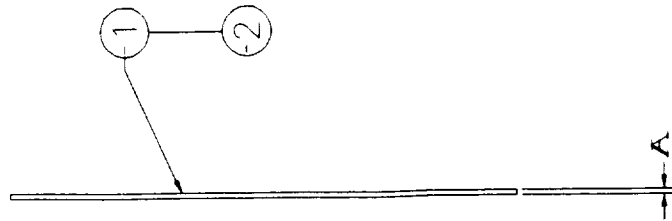
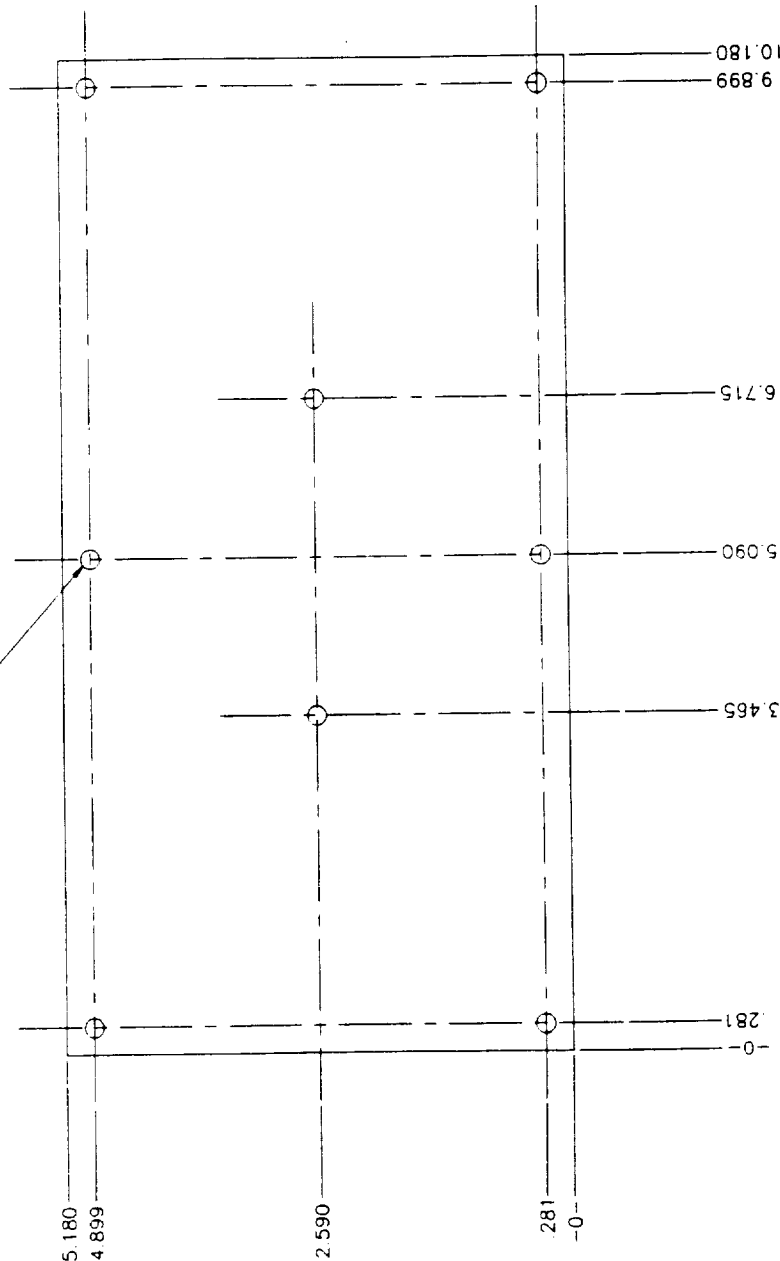
PROJECT	UNLESS OTHERWISE SPECIFIED TOLERANCES ARE:
DIM. ENDING .00 ± .030	ANGULAR DIM ± 30 MIN
DIM. ENDING .000 ± .005	



DASH NO.	NAME	A. DIM.	REQ'D
-1	SHIELD	.020	3
-2	TOP PLATE	.050	1

LETTER G (2610) DIA THRU  
8 HOLES FOR -1 SHIELDS

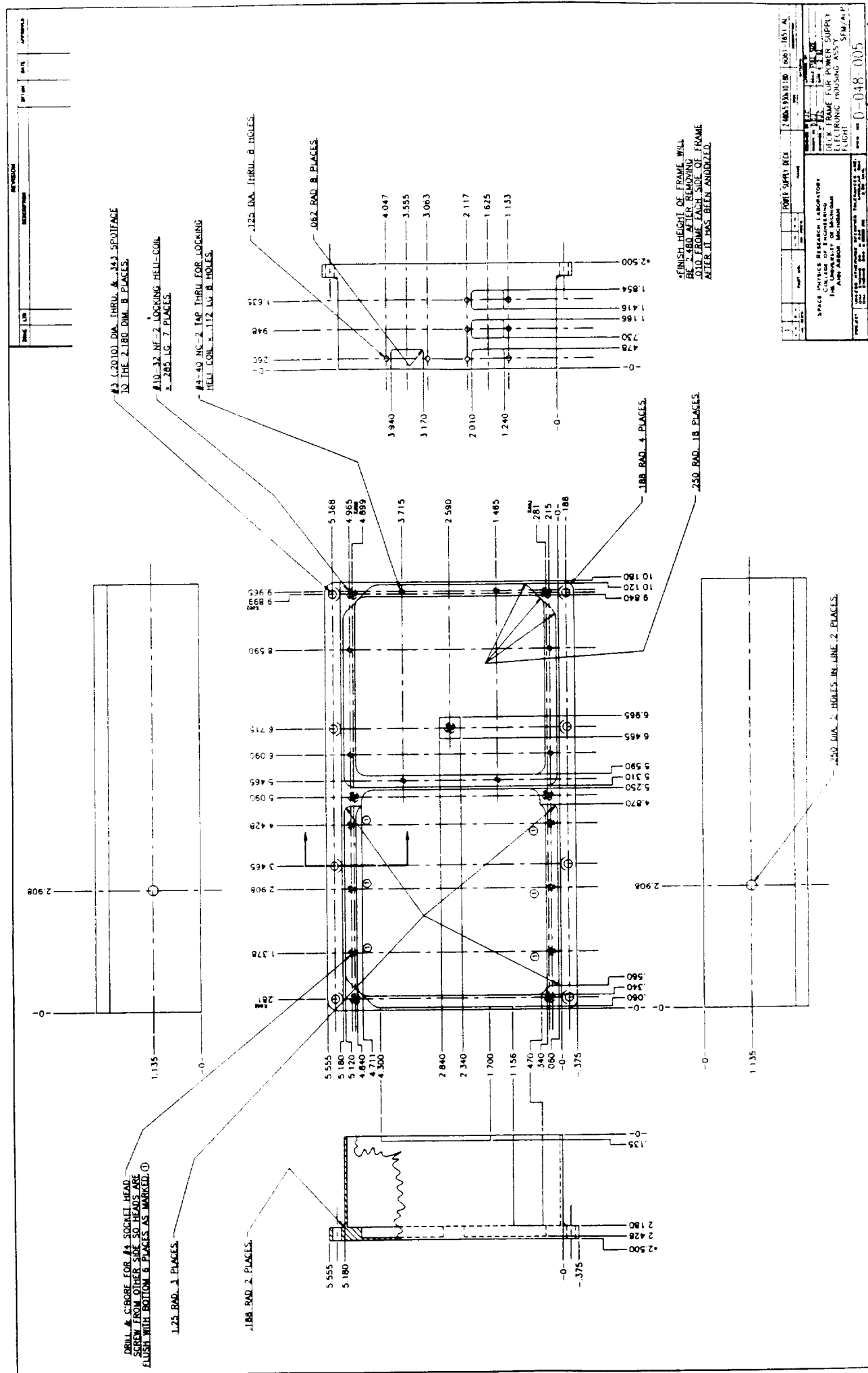
#7 (2010) DIA THRU  
8 HOLES FOR -2 TOP PLATE



- NOTE:
1. ALL HOLE DIM. 002
  2. FINISH CHROMATE CONVERSION
  3. BLACK ANODIZE -2 TOP PLATE

A		PART NO.		L. N. NO. REQ.		NAME		SHIELD/TOP PLATE		A. 5.180x10.180 6061-1651 AL	
NO. REQ.		NO. REQ.		NO. REQ.		NO. REQ.		NO. REQ.		NO. REQ.	
PROJECT		UNLESS OTHERWISE SPECIFIED TOLERANCES ARE:		DIM. ENDING .000		DOW. NO. C-048-004		DOW. NO. C-048-004		DOW. NO. C-048-004	
SPACE PHYSICS RESEARCH LABORATORY		COLLEGE OF ENGINEERING		THE UNIVERSITY OF MICHIGAN		ANN ARBOR, MICHIGAN		DECK SHIELD & TOP PLATE		ELECTRONIC HOUSING ASSY	
DESIGNED BY: DDJ		CHECKED BY: DDJ		DATE: JULY 5-92		DATE: JULY 5-92		DATE: JULY 5-92		DATE: JULY 5-92	
PROJECT		UNLESS OTHERWISE SPECIFIED TOLERANCES ARE:		DIM. ENDING .000		DOW. NO. C-048-004		DOW. NO. C-048-004		DOW. NO. C-048-004	

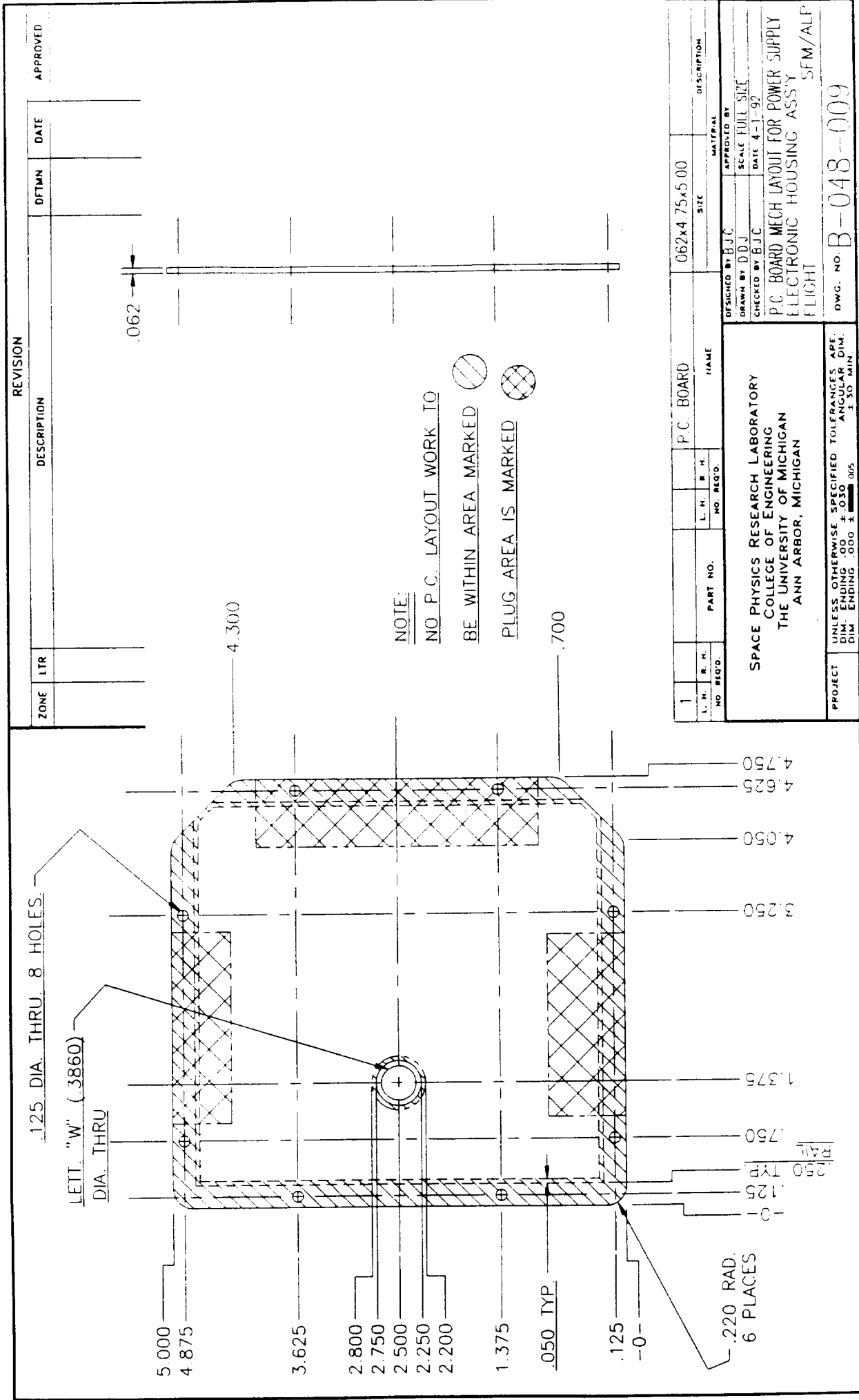
MAY 18 1992



•FINISH HEIGHT OF FRAME WILL BE 2'480 AFTER REMOVING .010 FROM EACH SIDE OF FRAME AFTER IT HAS BEEN ANODIZED.







REVISION				APPROVED	
ZONE	LTR	DESCRIPTION	DFTMN	DATE	

1	L. H.	R. H.	PART NO.	L. H.	R. H.	NO. REQ'D.	NAME	SIZE	MATERIAL	DESCRIPTION
							P.C. BOARD	062x4.75x5.00		

DESIGNED BY BJC	APPROVED BY
DRAWN BY BJC	SCALE FULL SIZE
CHECKED BY BJC	DATE 4-1-92

P.C. BOARD MECH LAYOUT FOR POWER SUPPLY  
ELECTRONIC HOUSING ASSY  
FLIGHT  
SFM/ALP

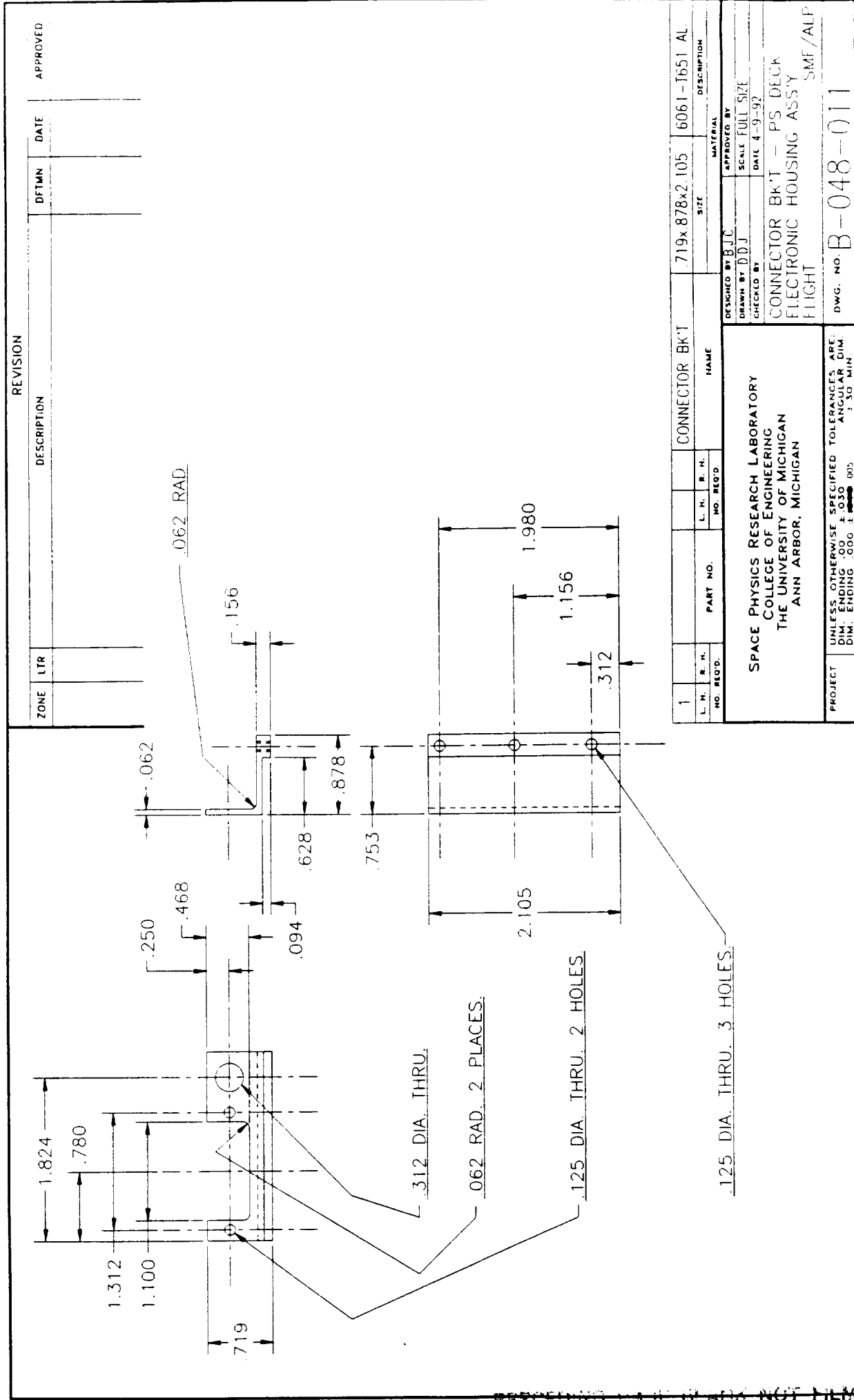
DWG. NO. B-048-009

UNLESS OTHERWISE SPECIFIED TOLERANCES ARE:  
DIM. ENDING .00 ± .030  
DIM. ENDING .000 ± .005  
ANGULAR DIM. ± 30 MIN.

PROJECT: SPACE PHYSICS RESEARCH LABORATORY  
COLLEGE OF ENGINEERING  
THE UNIVERSITY OF MICHIGAN  
ANN ARBOR, MICHIGAN

DATE: MAY 18 1992





REVISION		DESCRIPTION		DATE	
ZONE	LTR			DFTMN	APPROVED

1	L. H. NO. REQ'D.	R. H. NO. REQ'D.	PART NO.	NAME	CONNECTOR BK'T	719x 878x2 105	6061-T651 AL
				DESIGNED BY	BJC	SCALE	FULL SIZE
				DRAWN BY	DDJ	DATE	4-9-92
				CHECKED BY			
				CONNECTION BK'T - PS DECK			
				ELECTRONIC HOUSING ASSY			
				FLIGHT			
				SMF/ALP			
				DWG. NO. B-048-011			

SPACE PHYSICS RESEARCH LABORATORY  
COLLEGE OF ENGINEERING  
THE UNIVERSITY OF MICHIGAN  
ANN ARBOR, MICHIGAN

UNLESS OTHERWISE SPECIFIED TOLERANCES ARE:  
DIM. ENDING .00 ± .030  
DIM. ENDING .000 ± .005

[illegible]

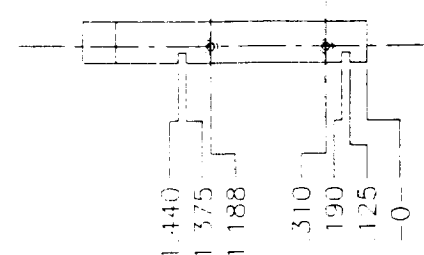
Technical drawing of a mechanical part, likely a piston or cylinder head, showing cross-sections and dimensions. The drawing includes a main view and a detail view of a hole. Dimensions are given in inches and millimeters. The part is labeled "SHORT SIDE PISTON" and "250 DIA. THRU".

**Dimensions (Inches):**

- Top view: 3.12, 1.87, 0
- Side view: 1.590, 1.780, 3.650
- Bottom view: 2.165, 1.915, 0
- Detail view: 1.440, 1.375, 1.188, 0.310, 0.190, 0.125, 0

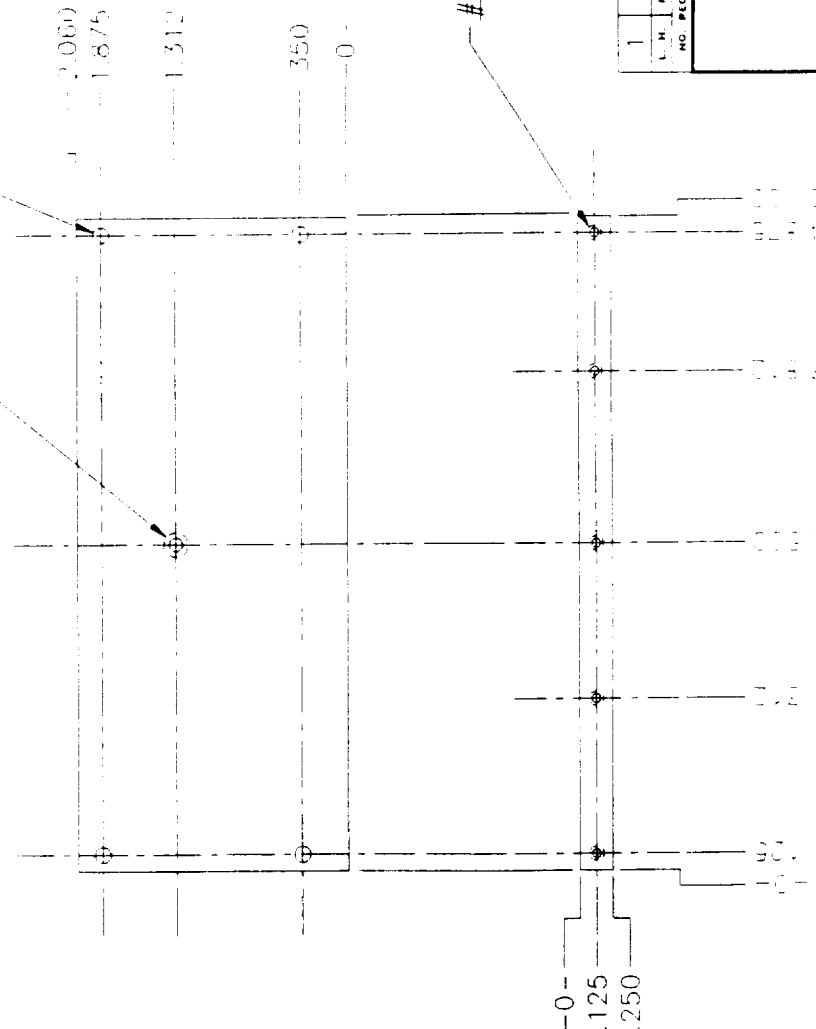
**Labels:**

- SHORT SIDE PISTON
- 250 DIA. THRU

[illegible]

1990

125 DIA 11K1.4 400000



NOTE: BLACK ALPHABET ML - A-G-Z

#4-40 NC-2 TAP x .312 DP. 5 HOLES.

[illegible]

[illegible]

NOTE: BLACK ANODIZE MIL A-86, 250 TYPE 2

## **APPENDIX D**

### **Measurement Mode Specifications**

# Modes of Operation

(revised October 7, 1992)

## I. Solar Flux Monitor

### 1) Standard EUV Measurement Mode:

G1 = - 25V

G2 = +25V

G3 = - 15V

Target = sweep from +20V to -36V in 1V steps (57 total)

Telemetry: 1 reading of Decade & Vernier settings, 57 A/D values  
= 1 word + 57 words = 58 words = 116 bytes

### 2) High Resolution EUV Measurement Mode:

G1 = - 25V

G2 = +25V

G3 = - 15V

Target = sweep from +20V to -36V in 0.25V steps (225 total)

Telemetry: 1 reading of Decade & Vernier settings, 225 A/D values  
= 1 word + 225 words = 226 words = 452 bytes

### 3) Grid 1 Test Mode:

G1 = - 35V, - 30V, - 25V, - 20V, - 15V

G2 = +25V

G3 = - 15V

Target = sweep from +20V to -36V in 2V steps (29 total)

Telemetry: 5 \* (1 reading of Decade & Vernier settings, 29 A/D values)  
= 5 \* (1 word + 29 words) = 150 words = 300 bytes

### 4) Grid 2 Test Mode:

G1 = - 25V

G2 = +15V, +20V, +25V, +30V, +35V

G3 = - 15V

Target = sweep from +20V to -36V in 2V steps (29 total)

Telemetry: 5 \* (1 reading of Decade & Vernier settings, 29 A/D values)  
= 5 \* (1 word + 29 words) = 150 words = 300 bytes

### 5) Grid 3 Test Mode:

G1 = - 25V

G2 = +25V

G3 = - 25V, - 20V, - 15V, - 10V, - 5V

Target = sweep from +20V to -36V in 2V steps (29 total)

Telemetry: 5 \* (1 reading of Decade & Vernier settings, 29 A/D values)  
= 5 \* (1 word + 29 words) = 150 words = 300 bytes

### 6) EUV Ion Retarding Potential Analyzer Mode:

G1 = - 10 V

G2 = sweep from -5V to +5V in 0.2V steps (51 total)

G3 = 0V

Target = 0V

Telemetry: 1 reading of Decade & Vernier settings, 51 A/D values  
= 1 word + 51 words = 52 words = 104 bytes

**7) EUV Electron Retarding Potential Analyzer Mode:**

G1 = +10 V

G2 = sweep from -5V to +5V in 0.2V steps (51 total)

G3 = 0V

Target = 0V

Telemetry: 1 reading of Decade & Vernier settings, 51 A/D values  
= 1 word + 51 words = 52 words = 104 bytes

**8) EUV Cleaning Mode 1 (5 seconds):**

G1 = + 50V

G2 = + 30V

G3 = + 15V

Target = +125V

Telemetry: None.

## II. Advanced Langmuir Probe

**1) Fast (5-point) ALP Mode:**

Probe  $V_a$  = values determined by algorithm (5 total)

Telemetry: 1 reading of Decade & Vernier settings, 1 reading of kTe,  
5 A/D & D/A values  
= 1 word + 1 word + 2 \* 5 words = 12 words = 24 bytes

**2) Standard ALP Sweep Mode:**

Probe  $V_a$  = sweep from -5 V to +5 V in 0.1V steps (101 total)

Telemetry: 1 reading of Decade & Vernier settings, 101 A/D values  
= 1 (16-bit) word + 101 words = 102 words = 204 bytes

**3) High Resolution ALP Sweep Mode:**

Probe  $V_a$  = sweep from -1.7V to +1.7V in 0.04V steps (86 total)

Telemetry: 1 reading of Decade & Vernier settings, 86 A/D values  
= 1 word + 86 words = 87 words = 174 bytes

**4) Medium Resolution ALP Sweep Mode:**

Probe  $V_a$  = sweep from -9kTe to +1kTe in kTe/8 steps (81 total), and a  
single reading at 2V above 1kTe

Telemetry: 1 reading of Decade & Vernier settings, 1 reading of kTe,  
81 A/D values  
= 1 word + 1 word + 81 words = 83 words  
= 166 bytes

**5) ALP Cleaning Mode 1 (5 seconds):**

Probe  $V_a$  = +125 V

Telemetry: None.

**Notes:**

- 1) All data will be transmitted in packet form. The telemetry requirements above do not include packet headers & terminators (start codes, mode ID, packet length, timestamp, checksum).
- 2) To avoid unnecessary redundancy, the housekeeping information will be sent in a separate packet.



## **Langmuir Probe Five-Point Algorithm**

1. Set  $V_a = V_1$  (initial value = -5.0 V)
2. Set preamp and vernier so that A/D measures  $I_1 = -3.3V$
3. Set  $V_a = V_3$  so that A/D measures  $I_3 = -0.4715 * I_1$
4. Set  $V_a = V_4$  so that A.D measures  $I_4 = -4.0 * I_1$  (max. +5.0V)
5. Set  $V_a = V_2 = V_1 + 2 * (V_4 - V_3)$  & measure  $I_2$
6. Set  $V_a = V_5 = V_4 + 7 * (V_4 - V_3)$  & measure  $I_5$
7. Compute new  $V_1 = -9 * (V_4 - V_3)$
8. Telemeter  $V_1, I_1, V_2, I_2, V_3, I_3, V_4, I_4, V_5, I_5$

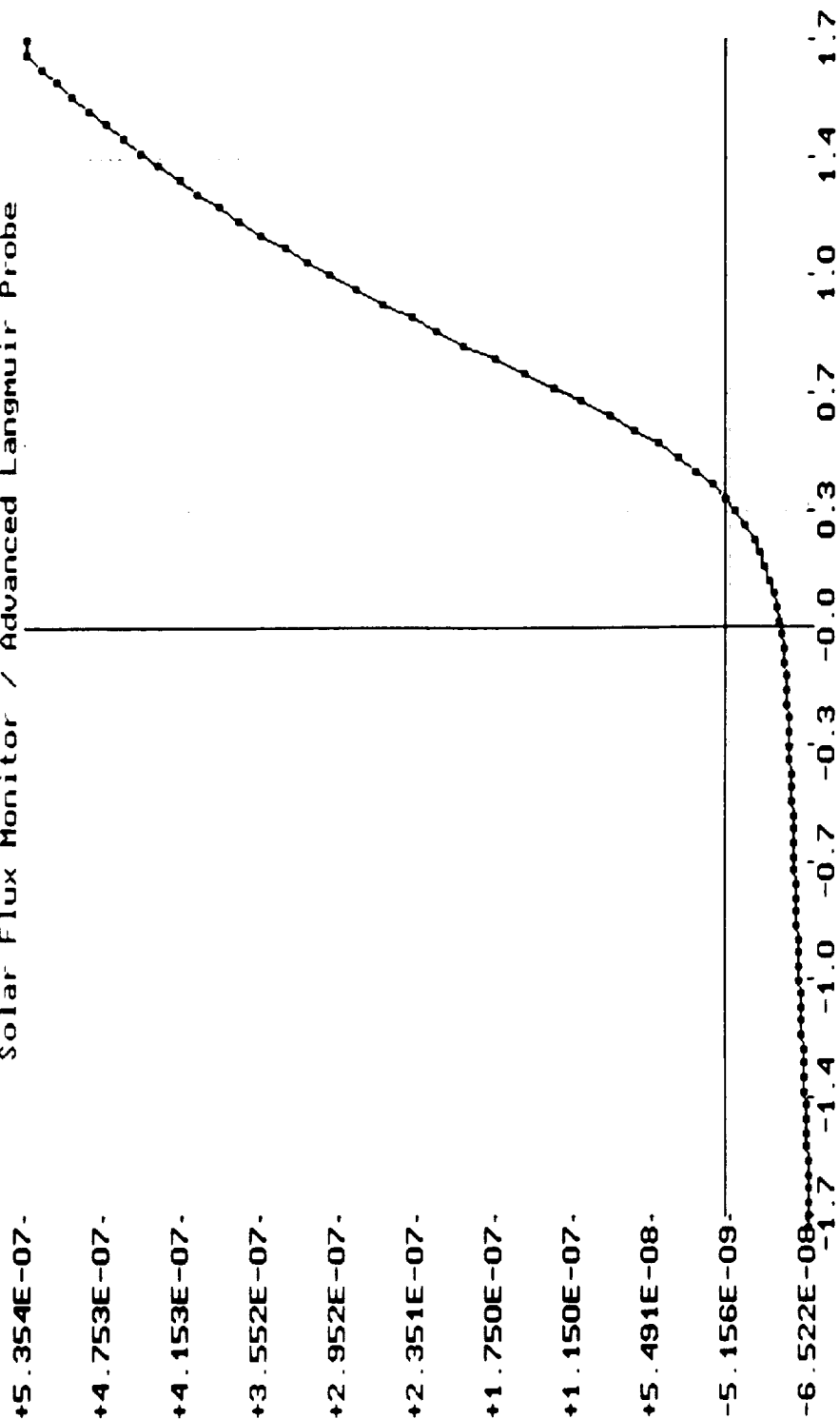
(For mode which sweeps from  $-9kT_e$  to  $+1kT_e$ ,  $kT_e = V_4 - V_3$ )

## **APPENDIX E**

### **Representative Data from Sounding Rocket Flight**



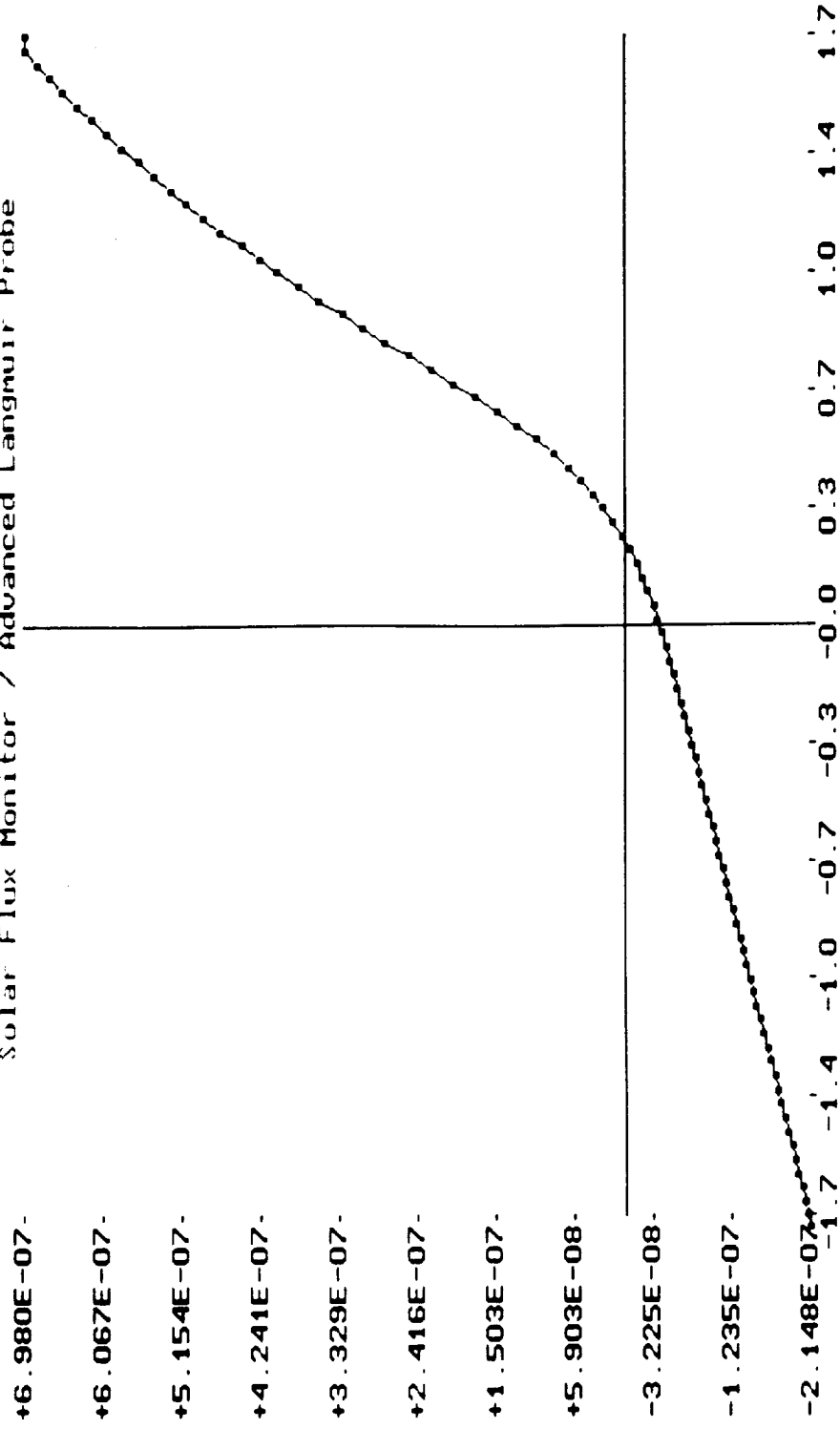
# Solar Flux Monitor / Advanced Langmuir Probe



Process ID  
 ALP\_PROC  
 Grid 1 (V) \*\*\*\*\*  
 Mode  
 ALP\_HR  
 Grid 2 (V) \*\*\*\*\*  
 Mode Start Time  
 10.305 = 2061  
 Grid 3 (V) \*\*\*\*\*  
 Altitude (m) \*\*\*\*\*  
 Pre/Uern Gain  
 0x1AFF  
 Target (U) \*\*\*\*\*

Telemetry Source - GOODTM.AL

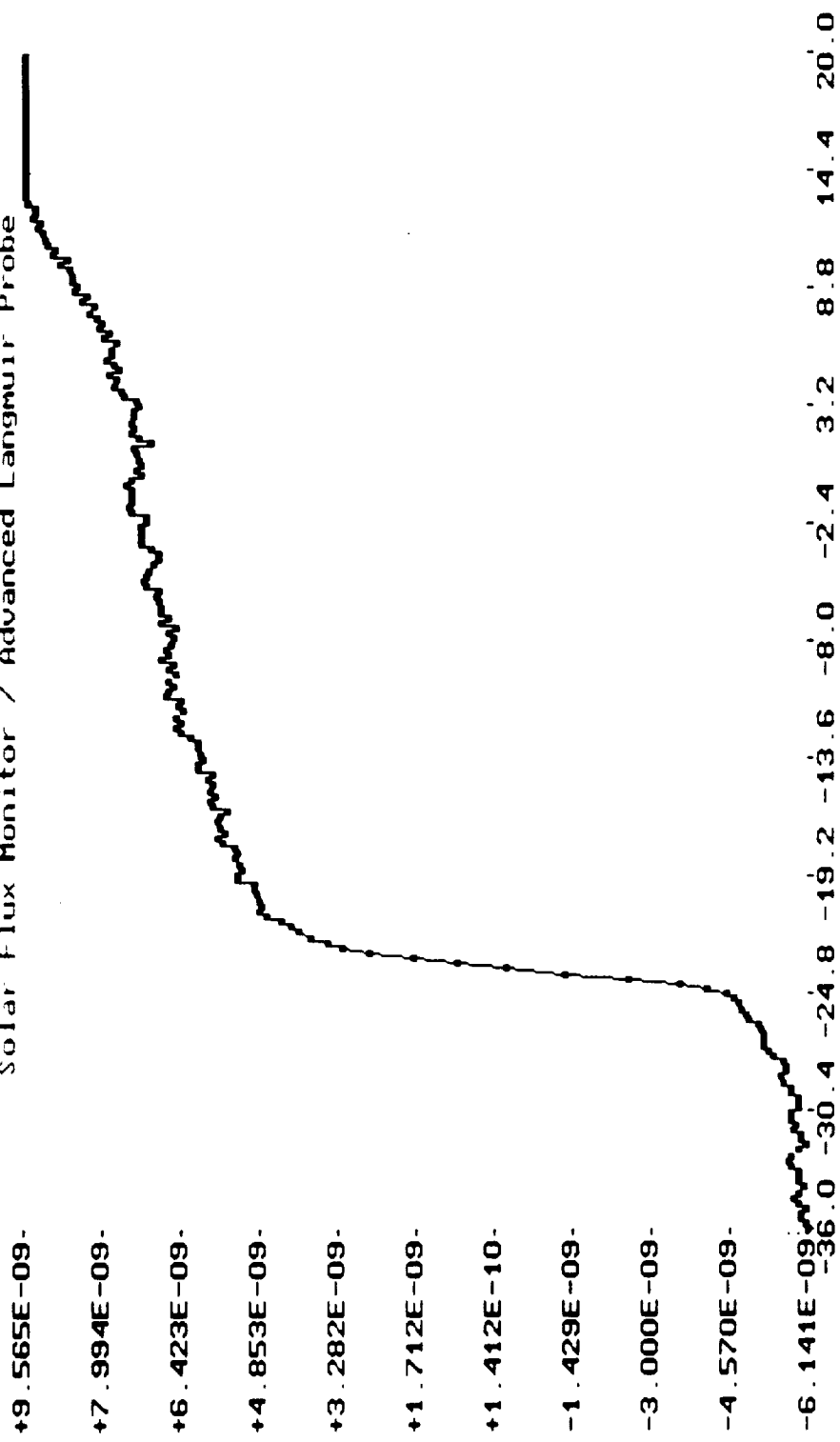
# Solar Flux Monitor / Advanced Langmuir Probe



Process ID  
 ALP\_PROC  
 Grid 1 (V)  
 \*\*\*\*\*  
 Mode  
 ALP\_HR  
 Grid 2 (V)  
 \*\*\*\*\*  
 Mode Start Time  
 7.730 = 1546  
 Grid 3 (V)  
 \*\*\*\*\*  
 Altitude (m)  
 \*\*\*\*\*  
 Pre/Uern Gain  
 0x1000  
 Target (V)  
 \*\*\*\*\*

Telemetry Source - GOODIM.ALP

# Solar Flux Monitor / Advanced Langmuir Probe



Process ID  
SFM\_PROC  
Grid 1 (V)  
-25.0

Mode  
SFM\_HR  
Grid 2 (V)  
+25.0

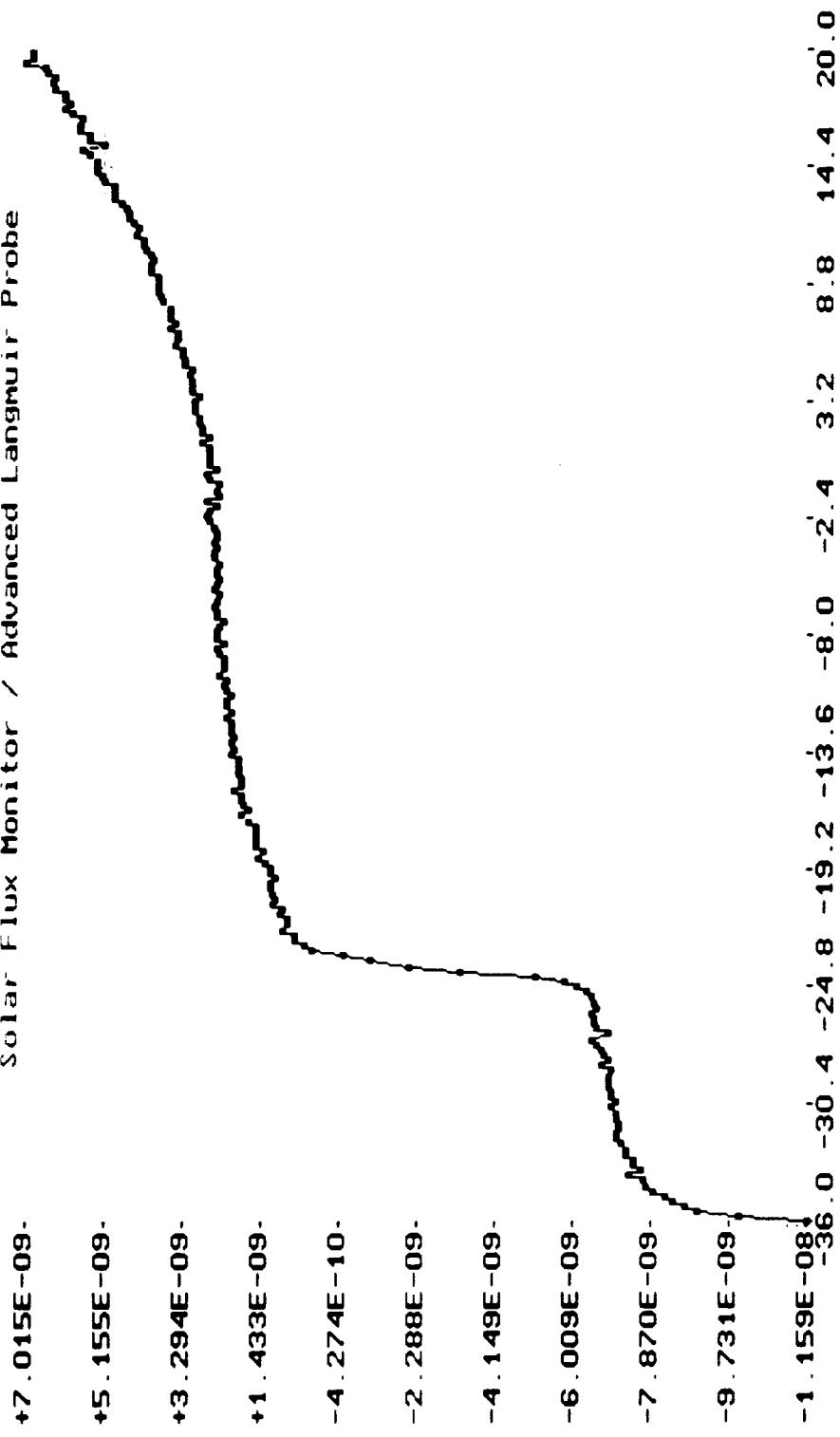
Mode Start Time  
300.355 = 60071  
Grid 3 (V)  
-15.0

Altitude (m)  
221622

Pre/Uern Gain  
0x3000  
Target (U)  
SNEEP

Telemetry Source - GOODTM.SFM

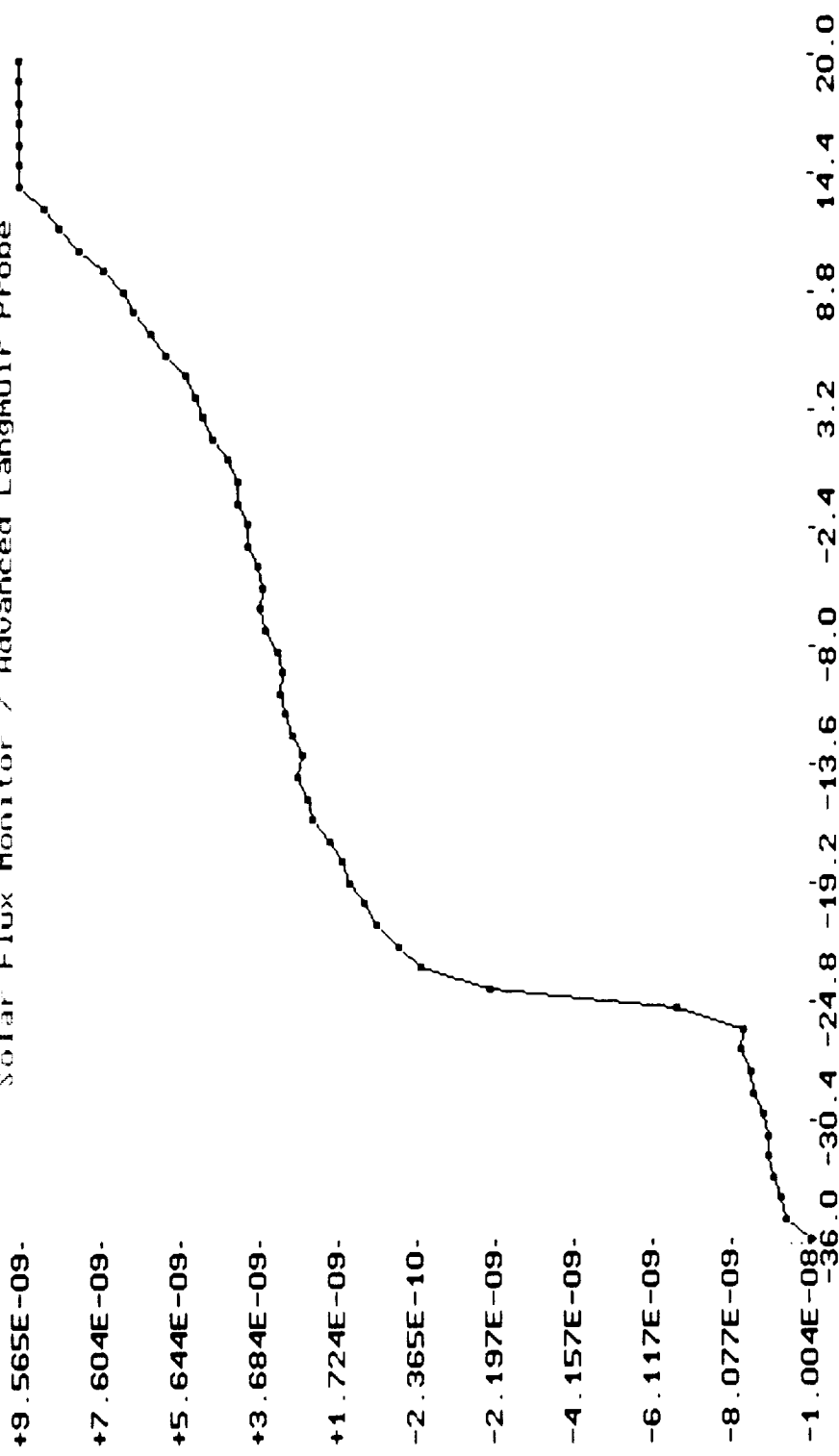
# Solar Flux Monitor / Advanced Langmuir Probe



Process ID	Mode	Mode Start Time	Altitude (m)	Pre/Uern Gain
SFM_PROC	SFM_HR	116.585 = 23317	149387	0x1000
Grid 1 (V)	Grid 2 (V)	Grid 3 (V)		Target (V)
-25.0	+25.0	-15.0		\$SWEET

Telemetry Source - GOODTM.SFM

# Solar Flux Monitor / Advanced Langmuir Probe



Process ID	Mode	Mode Start Time	Altitude (m)	Pre/Uern Gain
SFM_PROC	SFM_STD	304.950 = 60990	219322	0x3000
Grid_1 (V)	Grid_2 (V)	Grid_3 (V)		Target (U)
-25.0	+25.0	-15.0		SNEEP

Telemetry Source - GOODTM.SFM



